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(12) **United States Patent**
Kondow

(10) **Patent No.: US 9,392,277 B2**
(45) **Date of Patent: Jul. 12, 2016**

(54) **IMAGE PROCESSING DEVICE AND METHOD**

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(73) Assignee: **Sony Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 370 days.

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§ 371 (c)(1),
(2), (4) Date: **Jul. 22, 2013**

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PCT Pub. Date: **Aug. 16, 2012**

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(30) **Foreign Application Priority Data**

Feb. 7, 2011 (JP) 2011-023870

(51) **Int. Cl.**
H04N 7/12 (2006.01)
H04N 19/51 (2014.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04N 19/00587*** (2013.01); ***H04N 19/13*** (2014.11); ***H04N 19/463*** (2014.11); ***H04N 19/52*** (2014.11); *H04N 19/139* (2014.11)

(58) **Field of Classification Search**
CPC H04N 19/00587; H04N 19/52; H04N 19/463; H04N 19/13; H04N 19/139
USPC 375/240.16
See application file for complete search history.

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(Continued)

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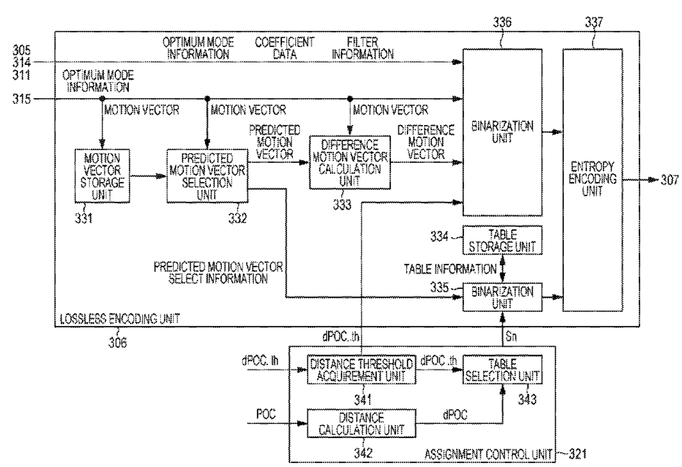
(74) *Attorney, Agent, or Firm* — Paratus Law Group, PLLC

(57) **ABSTRACT**

The present technique relates to an image processing device and method that can increase encoding efficiency. A table selection unit (**343**) compares the difference (distance) dPOC calculated by a distance calculation unit (**342**) with a distance threshold dPOC_th supplied from a distance threshold acquirement unit (**341**), and, in accordance with the comparison result, selects a table (a bit sequence assignment pattern) Sn. A binarization unit (**335**) refers to the table information about the assignment pattern (Sn) that is stored in a table storage unit (**334**) and is selected by a table selection unit (**343**), and, in accordance with the assignment pattern, binarizes the predicted motion vector select information (pmv_index) supplied from a predicted motion vector selection unit (**332**). The present invention can be applied to image processing devices, for example.

16 Claims, 38 Drawing Sheets



(51) **Int. Cl.**

H04N 19/13 (2014.01)
H04N 19/52 (2014.01)
H04N 19/463 (2014.01)
H04N 19/139 (2014.01)

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Jun. 17, 2015, EP communication issued for related EP application No. 12744571.6.
Kazushi Sato, On Motion Vector Coding, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, Jul. 21-28, 2010, pp. 1-9, 2nd Meeting: Geneva, CH.
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Feb. 17, 2015, EP communication issued for related EP application No. 12744571.6.
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Guillaume Laroche, et al., RD Optimized Coding for Motion Vector Predictor Selection, IEEE Transactions on Circuits and Systems for Video Technology, vol. 18, No. 9, Sep. 2008, pp. 1-11.
Jian-Liang Lin, et al., Improved Advanced Motion Vector Prediction, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, Jan. 20-28, 2011, pp. 1-8, 4th Meeting: Daegu, KR.
Sep. 8, 2015, JP communication issued for related JP application No. 2011-023870.
Feb. 2, 2016, Chinese Office Action for related CN Application No. 201280007255.X.
Apr. 26, 2016, Japanese Office Action for related JP Application No. 2011-023870.

* cited by examiner

FIG. 1

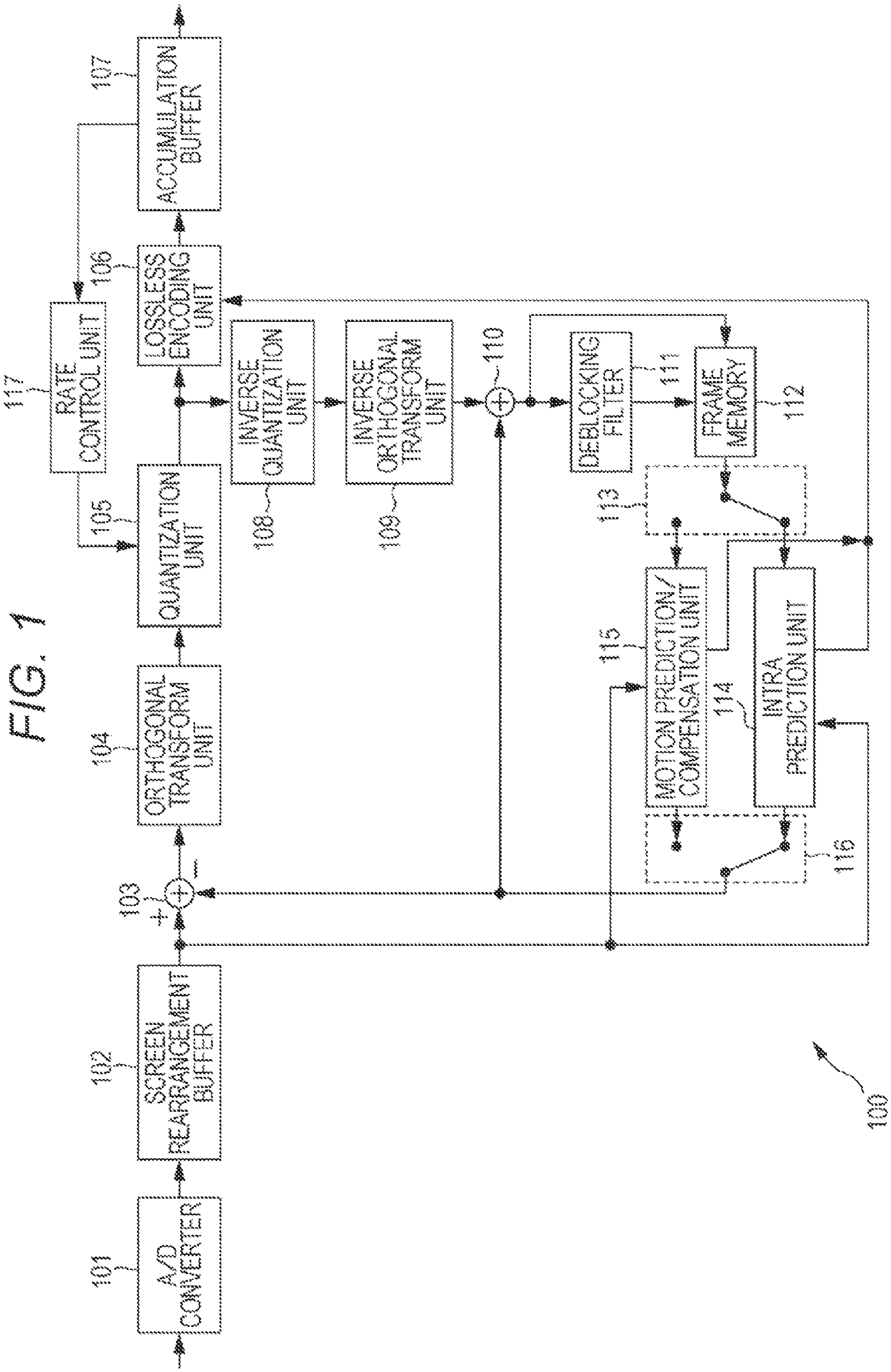

101
A/D CONVERTER
102
SCREEN REARRANGEMENT BUFFER
103
+
−
104
ORTHOGONAL TRANSFORM UNIT
105
QUANTIZATION UNIT
106
LOSSLESS ENCODING UNIT
107
ACCUMULATION BUFFER
117
RATE CONTROL UNIT
108
INVERSE QUANTIZATION UNIT
109
INVERSE ORTHOGONAL TRANSFORM UNIT
110
111
DEBLOCKING FILTER
112
FRAME MEMORY
113
115
MOTION PREDICTION/ COMPENSATION UNIT
114
INTRA PREDICTION UNIT
116
100

FIG. 2

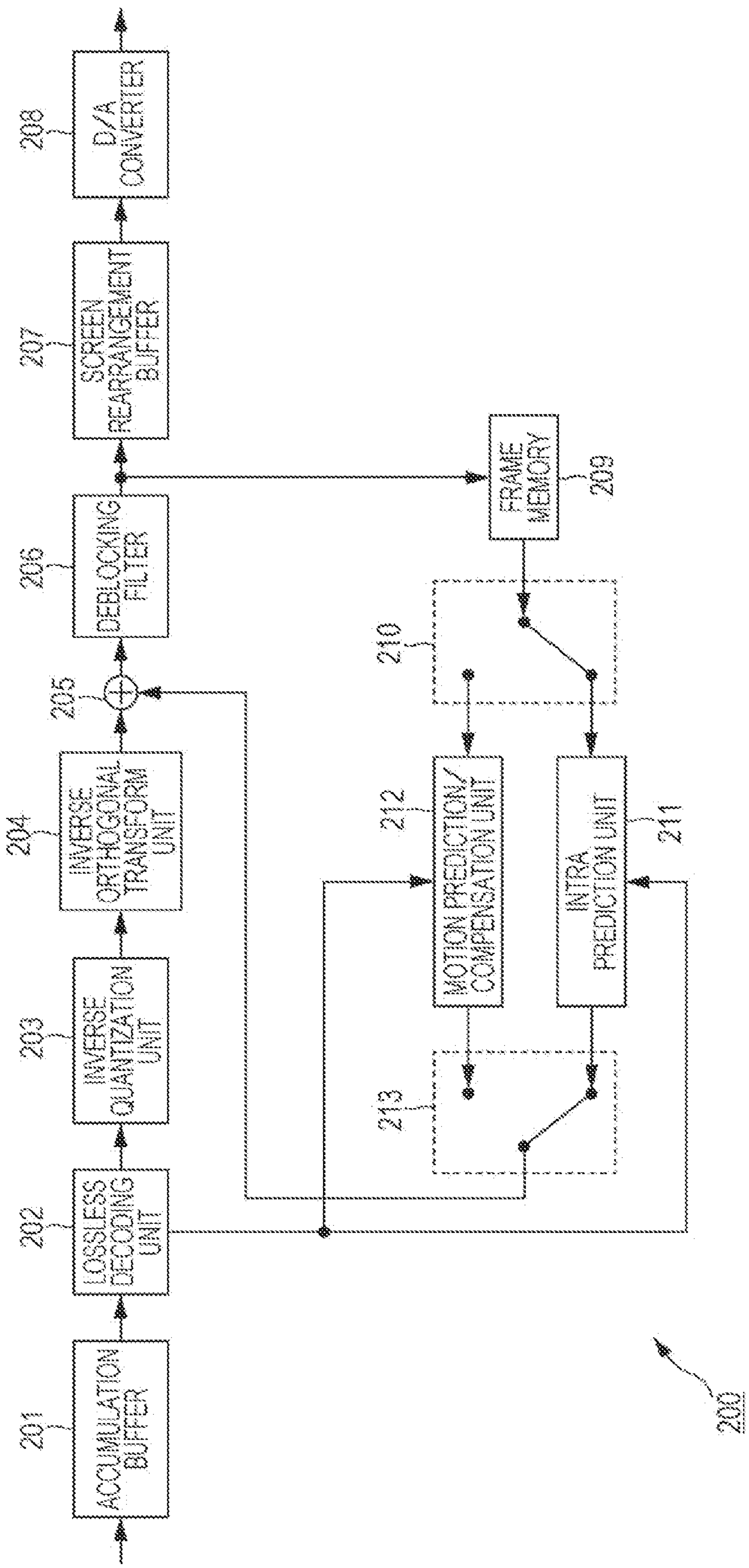

201
ACCUMULATION BUFFER
202
LOSSLESS DECODING UNIT
203
INVERSE QUANTIZATION UNIT
204
INVERSE ORTHOGONAL TRANSFORM UNIT
205
206
DEBLOCKING FILTER
207
SCREEN REARRANGEMENT BUFFER
208
D/A CONVERTER
209
FRAME MEMORY
210
211
INTRA PREDICTION UNIT
212
MOTION PREDICTION/ COMPENSATION UNIT
213
200

FIG. 3

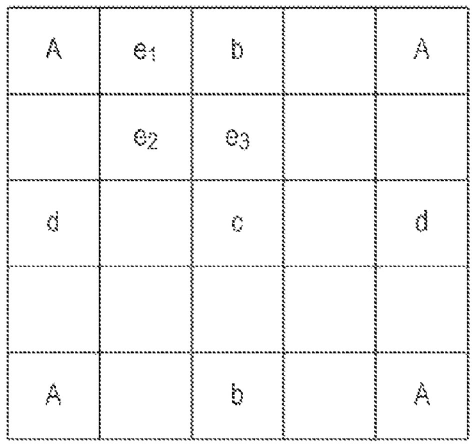

A
e_1
b
A
e_2
e_3
d
c
d
A
b
A

FIG. 4

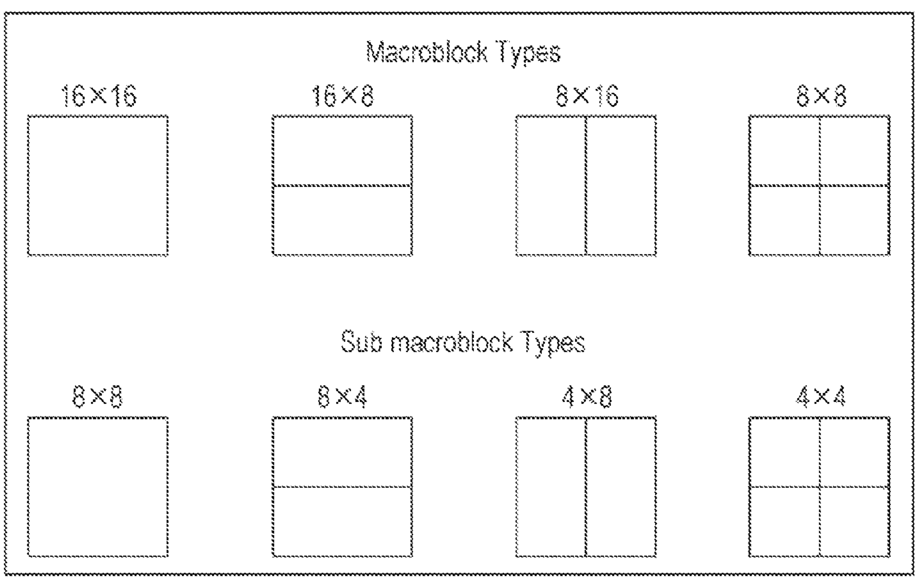

Macroblock Types
16×16
16×8
8×16
8×8
Sub macroblock Types
8×8
8×4
4×8
4×4

FIG. 5

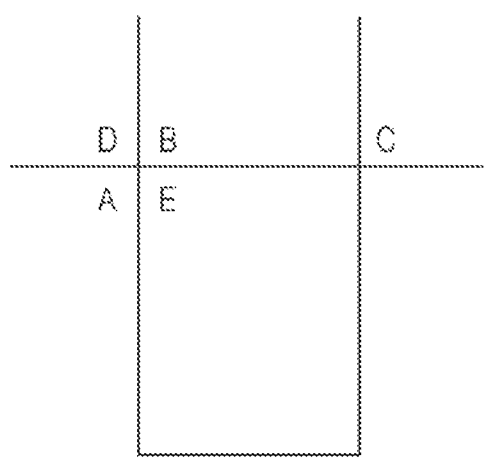


FIG. 6

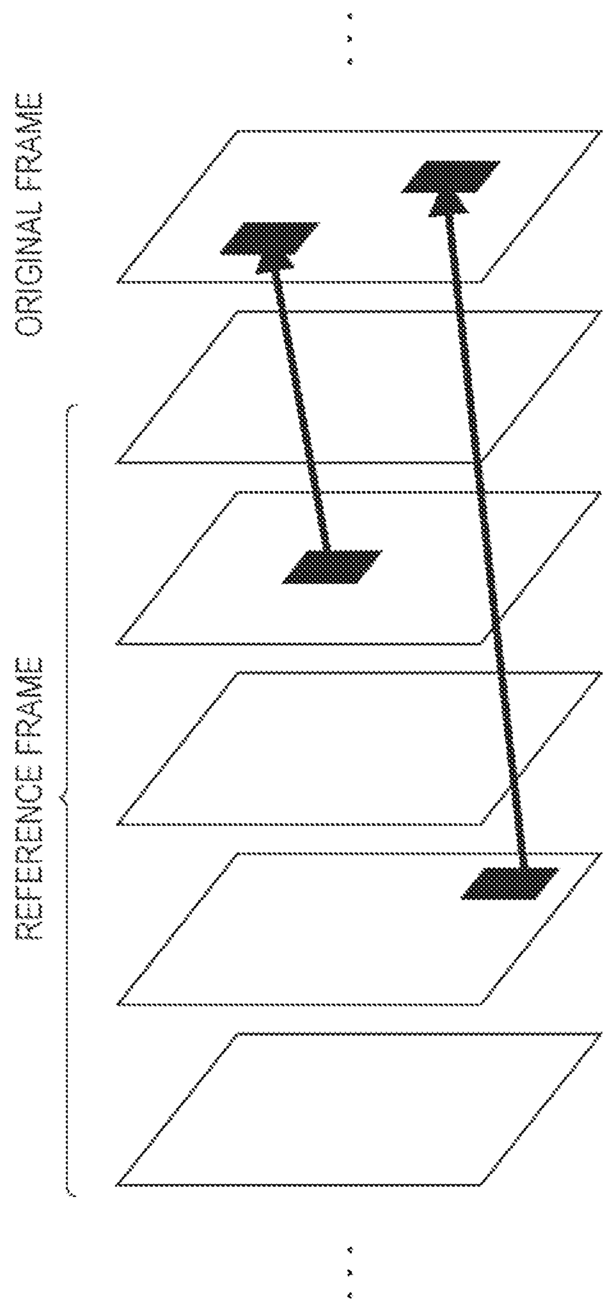


FIG. 7

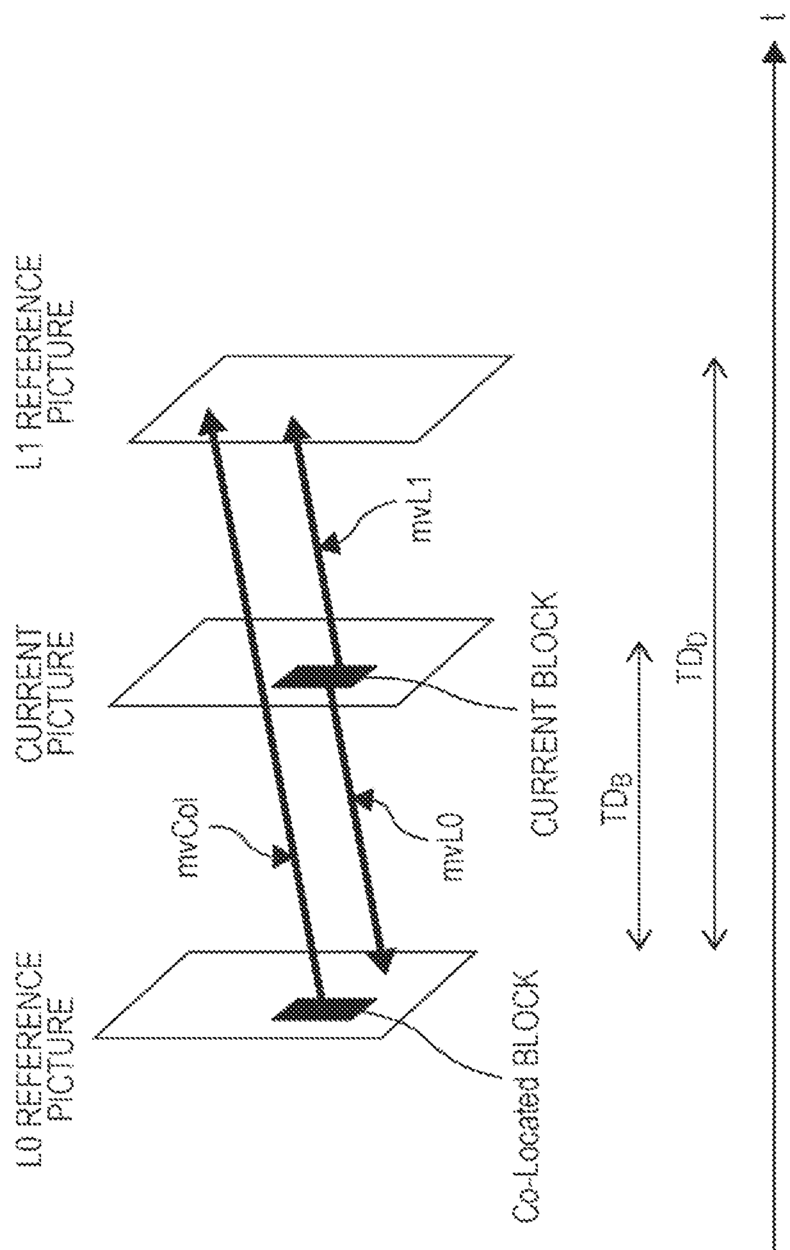

L0 REFERENCE PICTURE
CURRENT PICTURE
L1 REFERENCE PICTURE
mvCol
mvL0
mvL1
CURRENT BLOCK
Co-Located BLOCK
TD_B
TD_D
t

FIG. 8

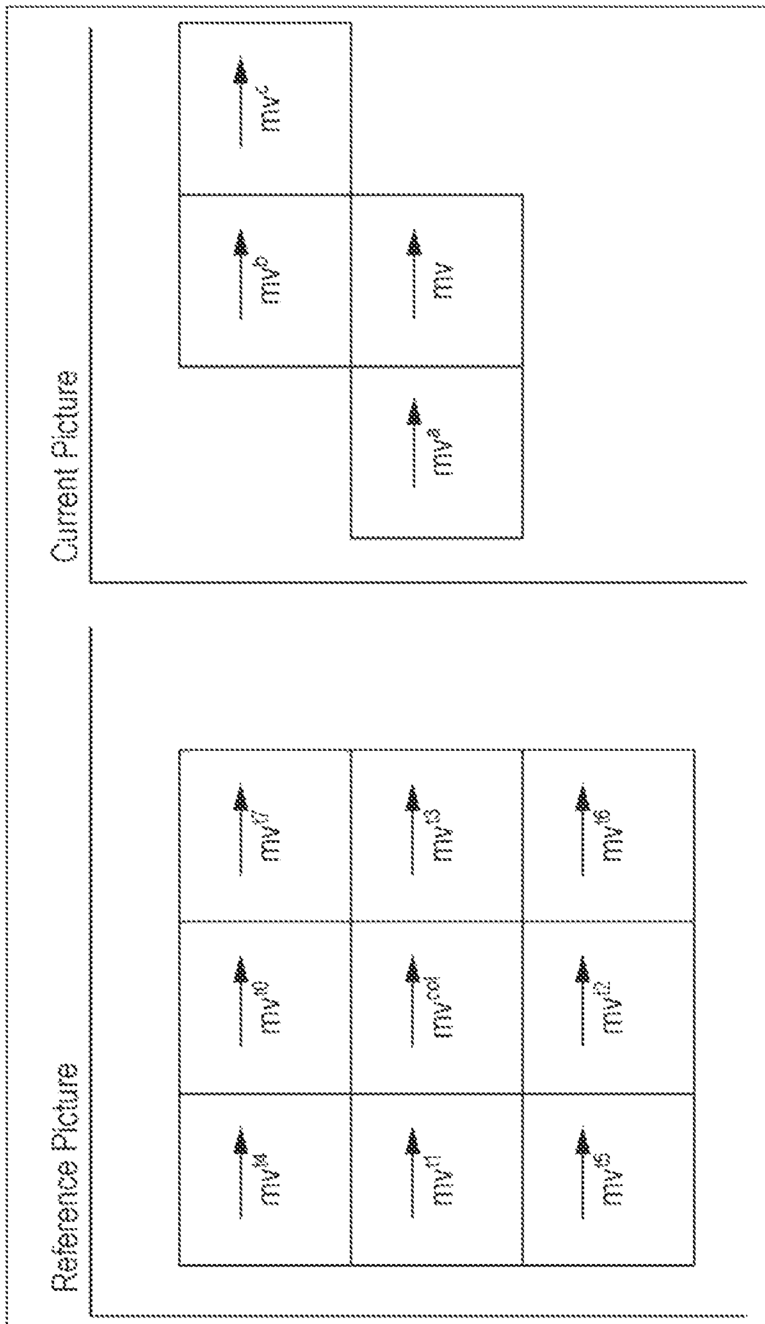

Current Picture
mv^c
mv^b
mv
mv^a
Reference Picture
mv^t7
mv^t3
mv^t6
mv^t0
mv^col
mv^t2
mv^t4
mv^t1
mv^t5

FIG. 9

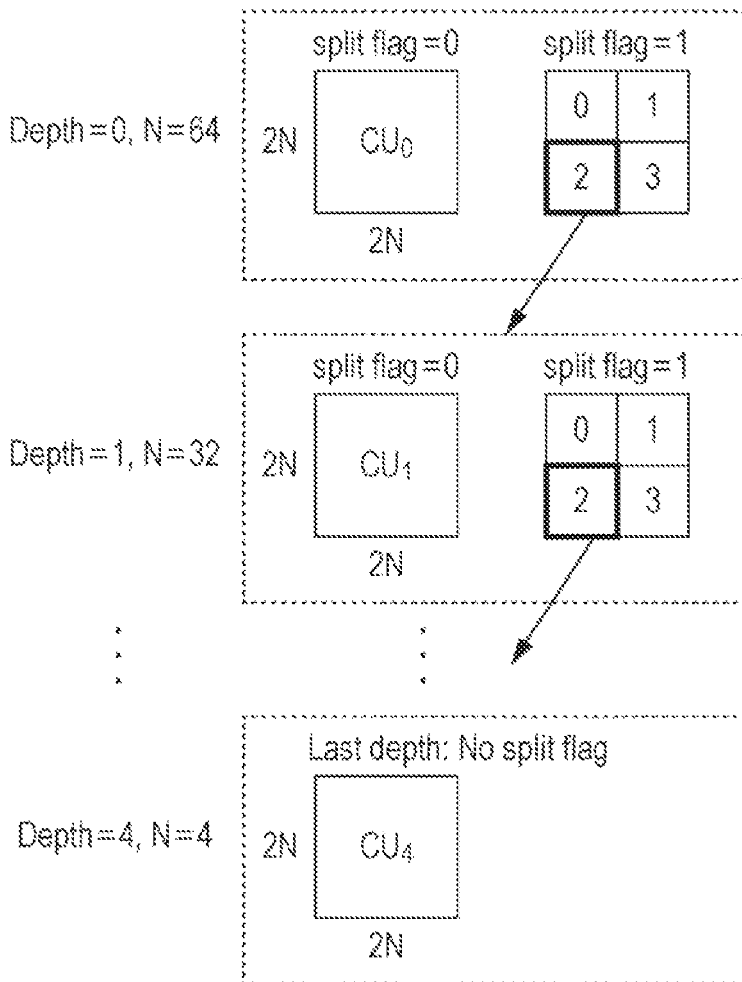

Depth=0, N=64
split flag=0
2N
CU_0
2N
split flag=1
0
1
2
3
Depth=1, N=32
split flag=0
2N
CU_1
2N
split flag=1
0
1
2
3
Last depth: No split flag
Depth=4, N=4
2N
CU_4
2N

FIG. 10

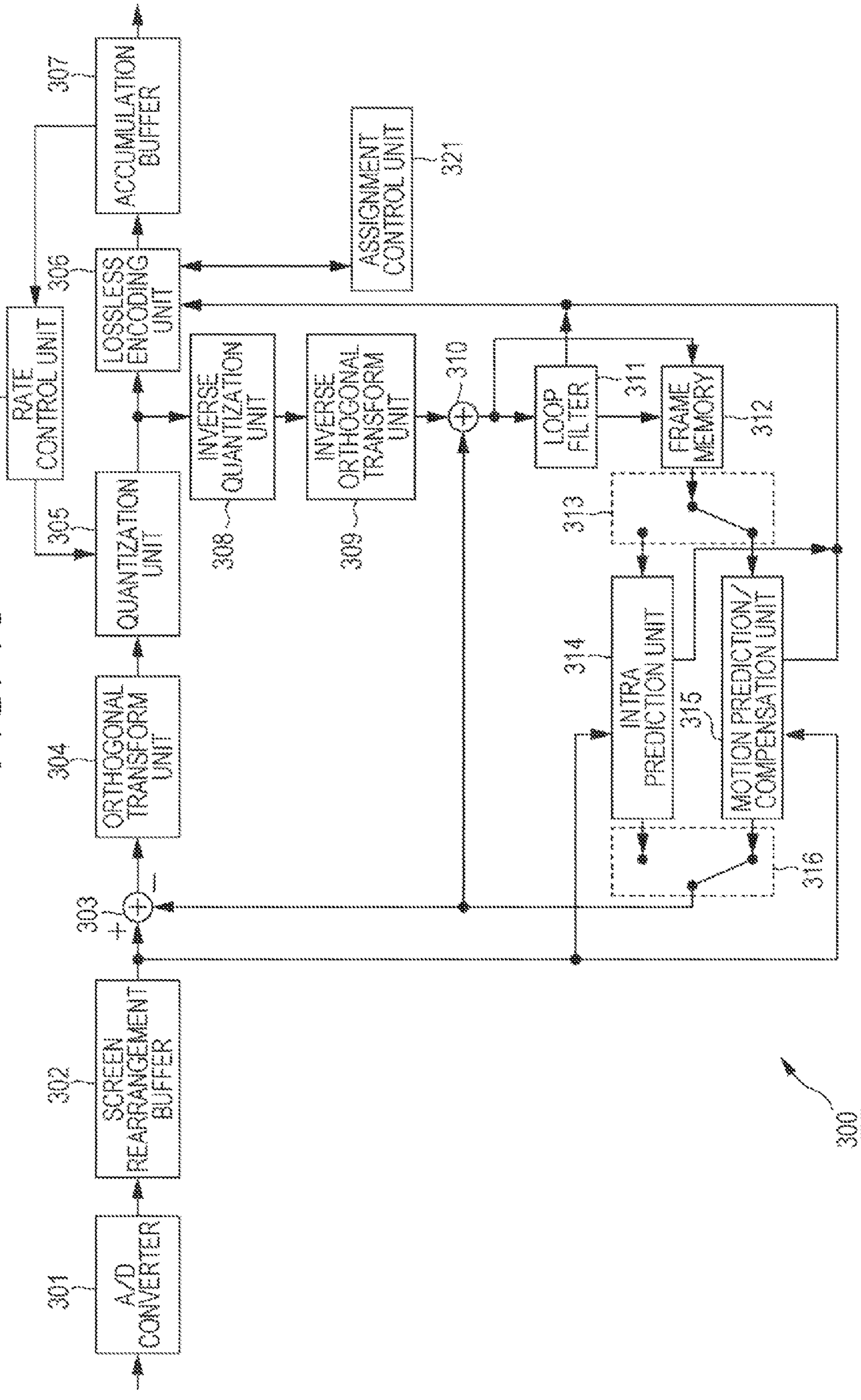

301
A/D CONVERTER
302
SCREEN REARRANGEMENT BUFFER
303
+
−
304
ORTHOGONAL TRANSFORM UNIT
305
QUANTIZATION UNIT
306
LOSSLESS ENCODING UNIT
307
ACCUMULATION BUFFER
308
INVERSE QUANTIZATION UNIT
309
INVERSE ORTHOGONAL TRANSFORM UNIT
310
311
LOOP FILTER
312
FRAME MEMORY
313
314
INTRA PREDICTION UNIT
315
MOTION PREDICTION/ COMPENSATION UNIT
316
317
RATE CONTROL UNIT
321
ASSIGNMENT CONTROL UNIT
300

FIG. 11

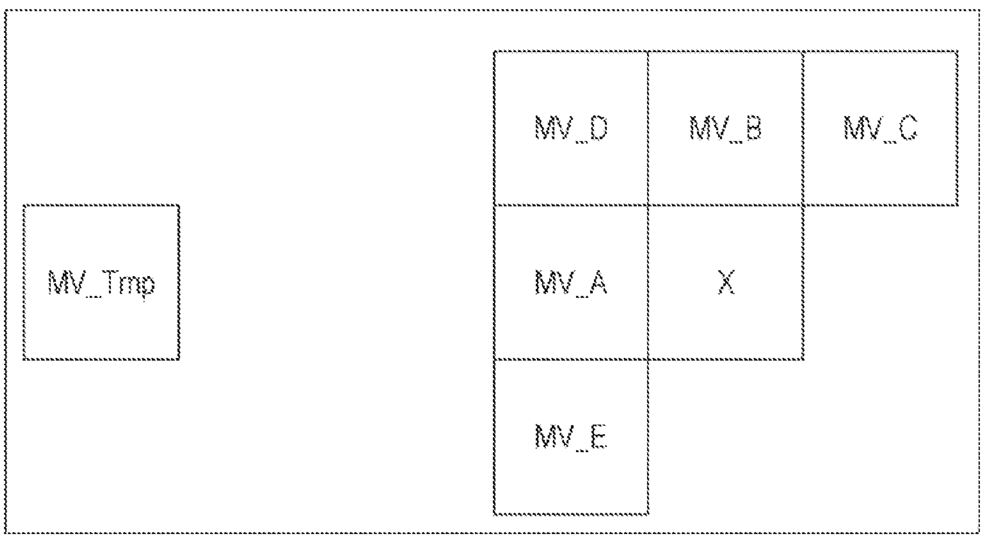


FIG. 12

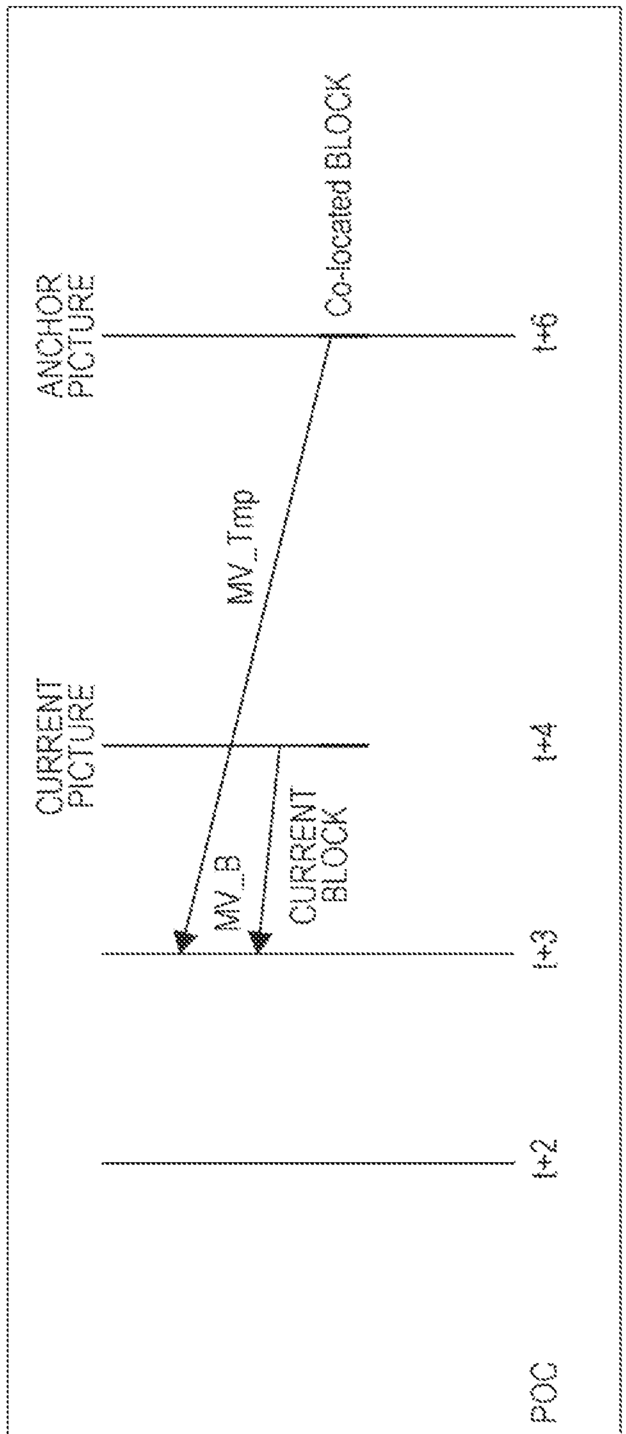

ANCHOR PICTURE
Co-located BLOCK
MV_Tmp
CURRENT PICTURE
CURRENT BLOCK
MV_B
POC
t+2
t+3
t+4
t+6

FIG. 13

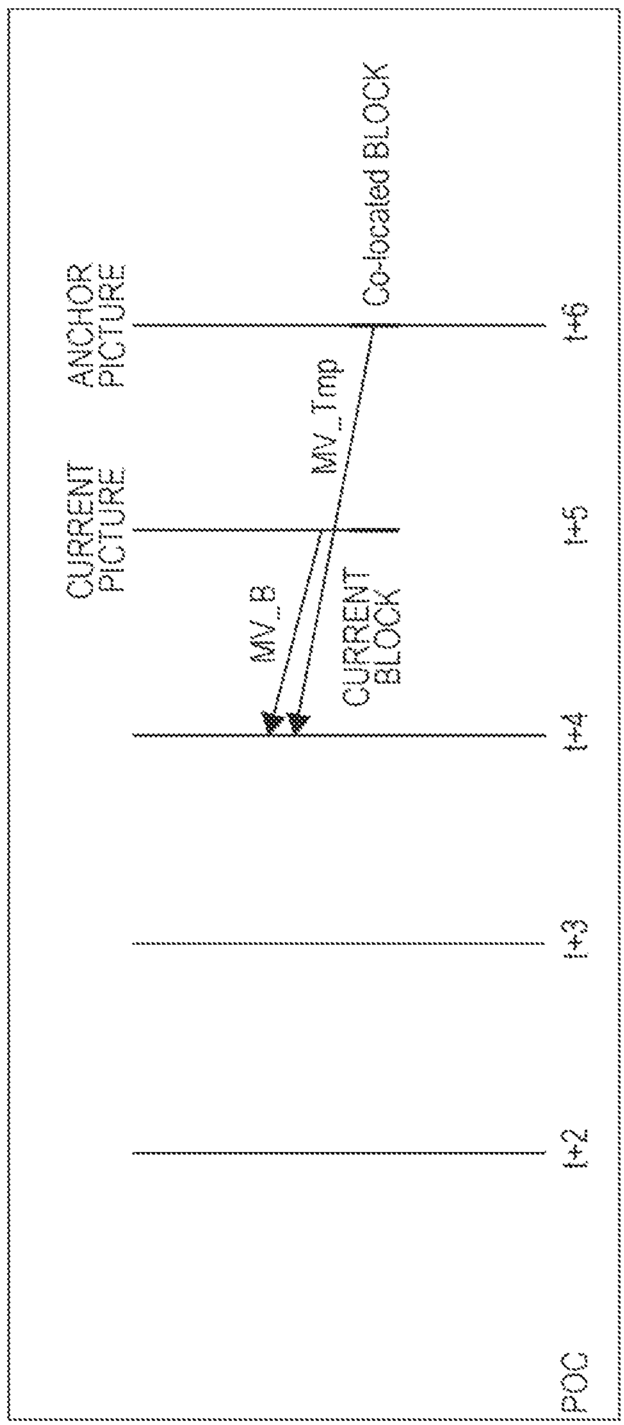

ANCHOR PICTURE
CURRENT PICTURE
Co-located BLOCK
MV_Tmp
MV_B
CURRENT BLOCK
t+6
t+5
t+4
t+3
t+2
POC

FIG. 14

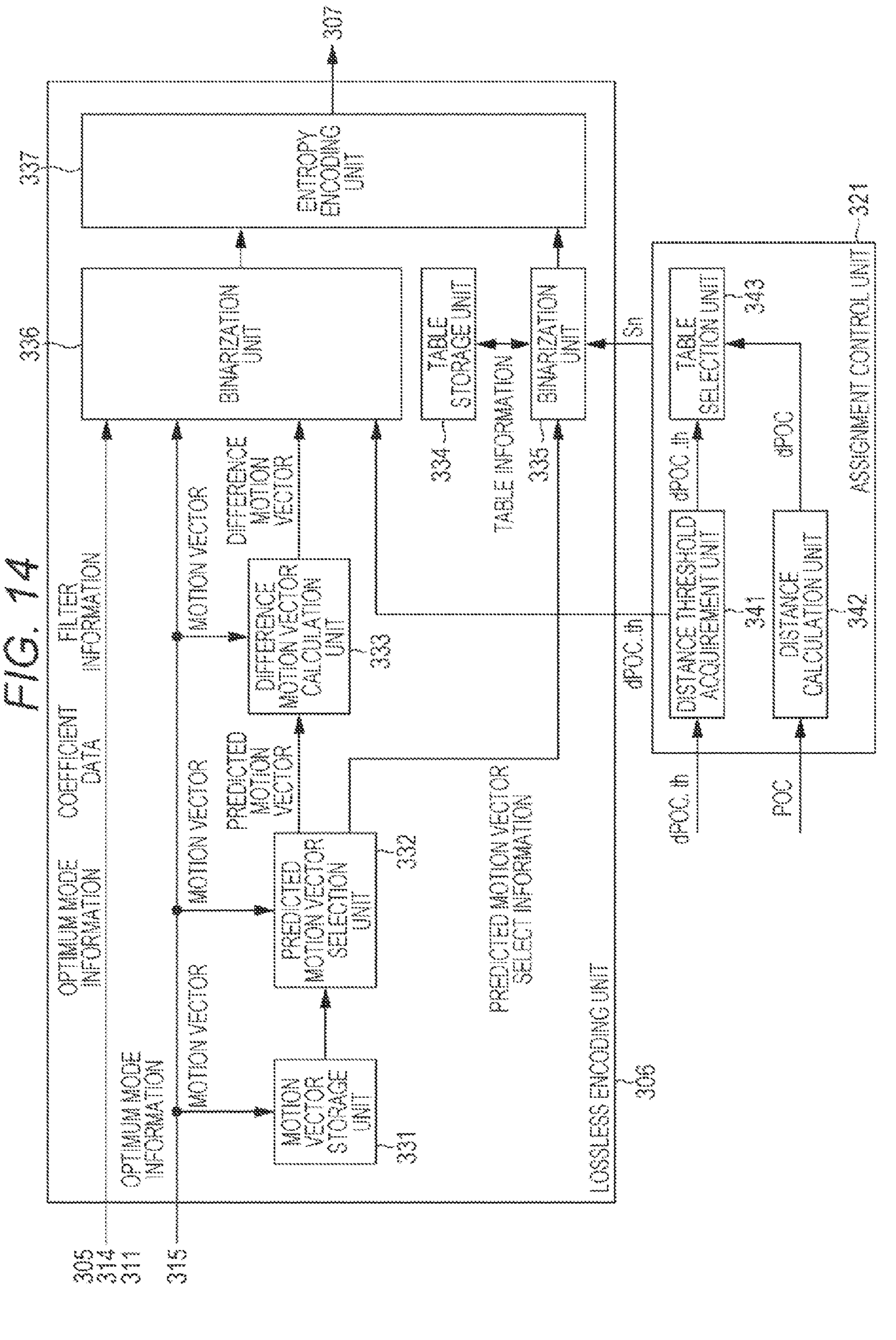
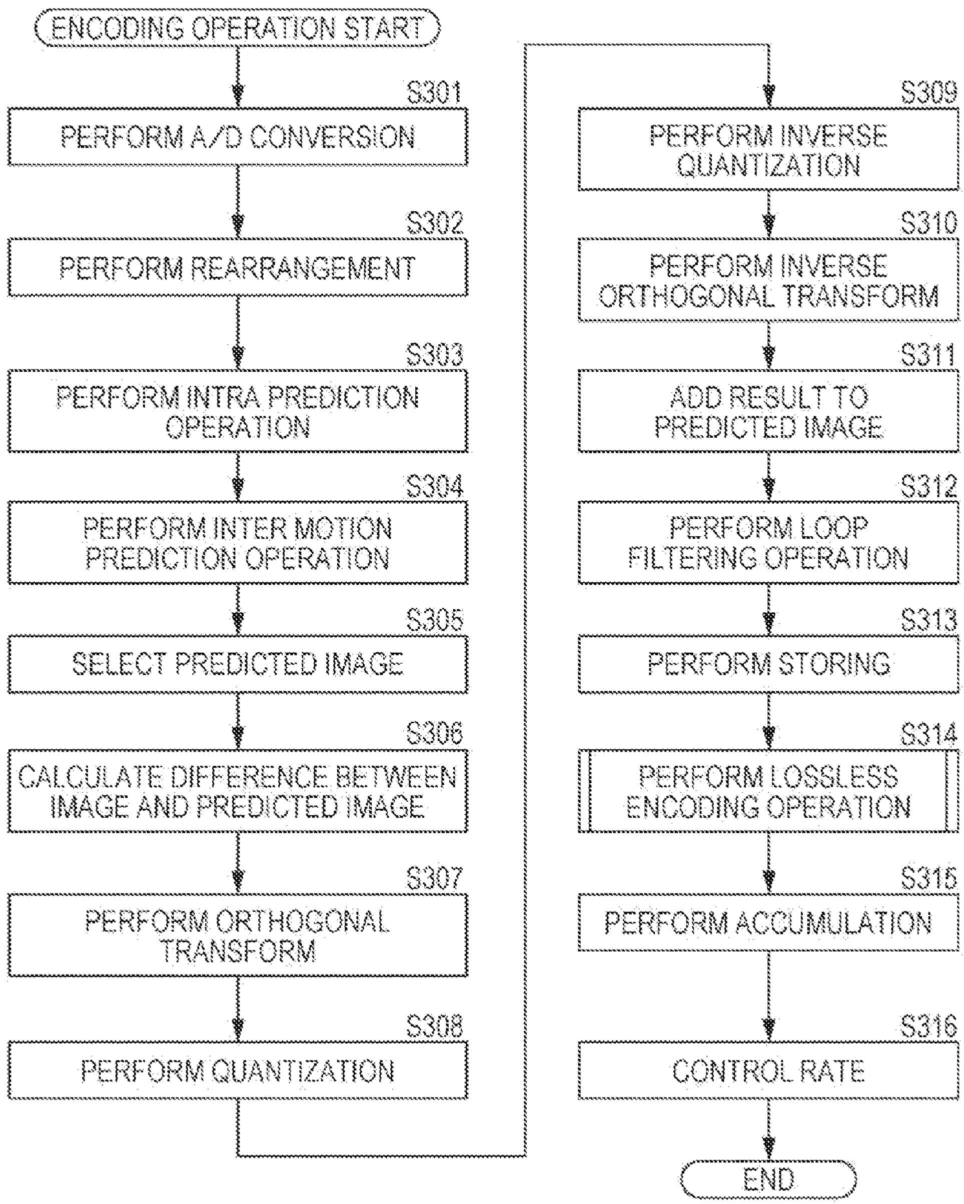

307
337
ENTROPY ENCODING UNIT
336
BINARIZATION UNIT
TABLE STORAGE UNIT
334
BINARIZATION UNIT
335
TABLE INFORMATION
Sn
321
ASSIGNMENT CONTROL UNIT
TABLE SELECTION UNIT
343
dPOC_th
dPOC
DISTANCE THRESHOLD ACQUIREMENT UNIT
341
DISTANCE CALCULATION UNIT
342
dPOC_th
POC
DIFFERENCE MOTION VECTOR
MOTION VECTOR
FILTER INFORMATION
DIFFERENCE MOTION VECTOR CALCULATION UNIT
333
COEFFICIENT DATA
PREDICTED MOTION VECTOR
MOTION VECTOR
OPTIMUM MODE INFORMATION
PREDICTED MOTION VECTOR SELECTION UNIT
332
PREDICTED MOTION VECTOR SELECT INFORMATION
MOTION VECTOR
OPTIMUM MODE INFORMATION
MOTION VECTOR STORAGE UNIT
331
LOSSLESS ENCODING UNIT
306
305
314
311
315

FIG. 15

CODE NUMBER	BIT SEQUENCE	S1	S2
0	1	Median	MV_Tmp
1	010	MV_A	Median
2	011	MV_B	MV_A
3	00100	MV_C	MV_B
4	00101	MV_E	MV_C
5	00110	MV_D	MV_E
6	00111	MV_Tmp	MV_D

FIG. 16



ENCODING OPERATION START
S301
PERFORM A/D CONVERSION
S302
PERFORM REARRANGEMENT
S303
PERFORM INTRA PREDICTION OPERATION
S304
PERFORM INTER MOTION PREDICTION OPERATION
S305
SELECT PREDICTED IMAGE
S306
CALCULATE DIFFERENCE BETWEEN IMAGE AND PREDICTED IMAGE
S307
PERFORM ORTHOGONAL TRANSFORM
S308
PERFORM QUANTIZATION
S309
PERFORM INVERSE QUANTIZATION
S310
PERFORM INVERSE ORTHOGONAL TRANSFORM
S311
ADD RESULT TO PREDICTED IMAGE
S312
PERFORM LOOP FILTERING OPERATION
S313
PERFORM STORING
S314
PERFORM LOSSLESS ENCODING OPERATION
S315
PERFORM ACCUMULATION
S316
CONTROL RATE
END

FIG. 17

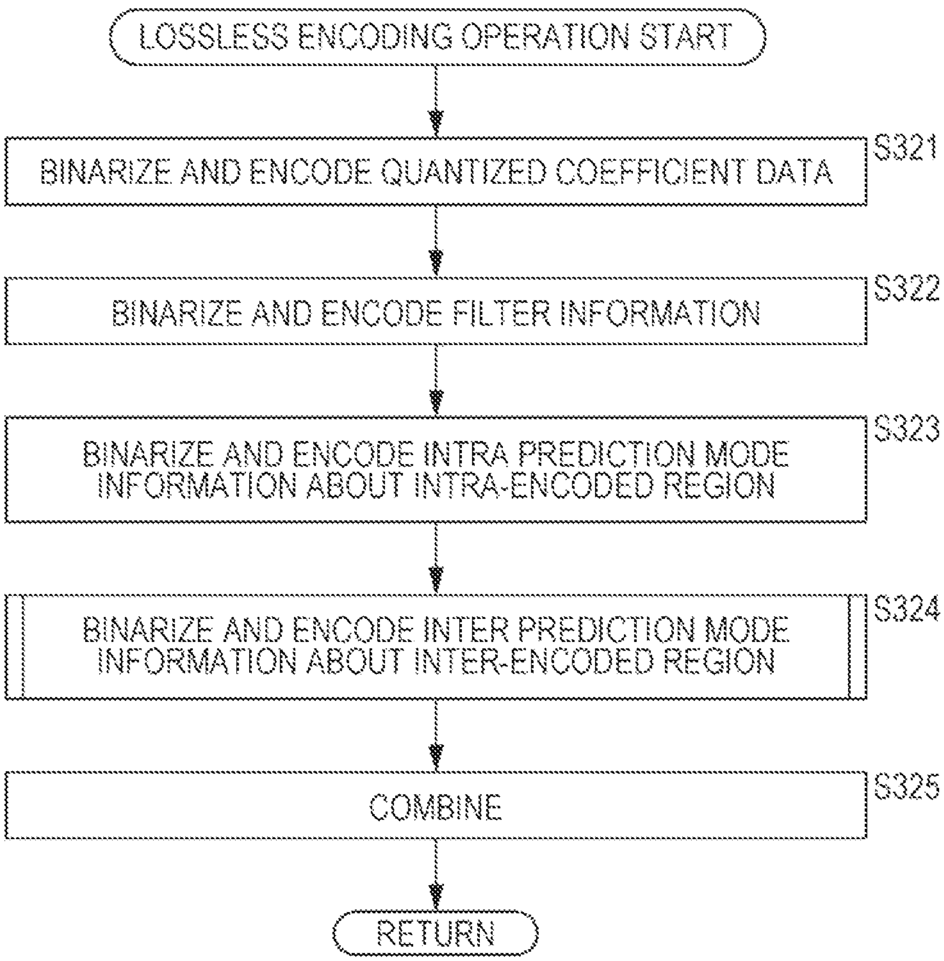

LOSSLESS ENCODING OPERATION START
BINARIZE AND ENCODE QUANTIZED COEFFICIENT DATA
S321
BINARIZE AND ENCODE FILTER INFORMATION
S322
BINARIZE AND ENCODE INTRA PREDICTION MODE INFORMATION ABOUT INTRA-ENCODED REGION
S323
BINARIZE AND ENCODE INTER PREDICTION MODE INFORMATION ABOUT INTER-ENCODED REGION
S324
COMBINE
S325
RETURN

FIG. 18

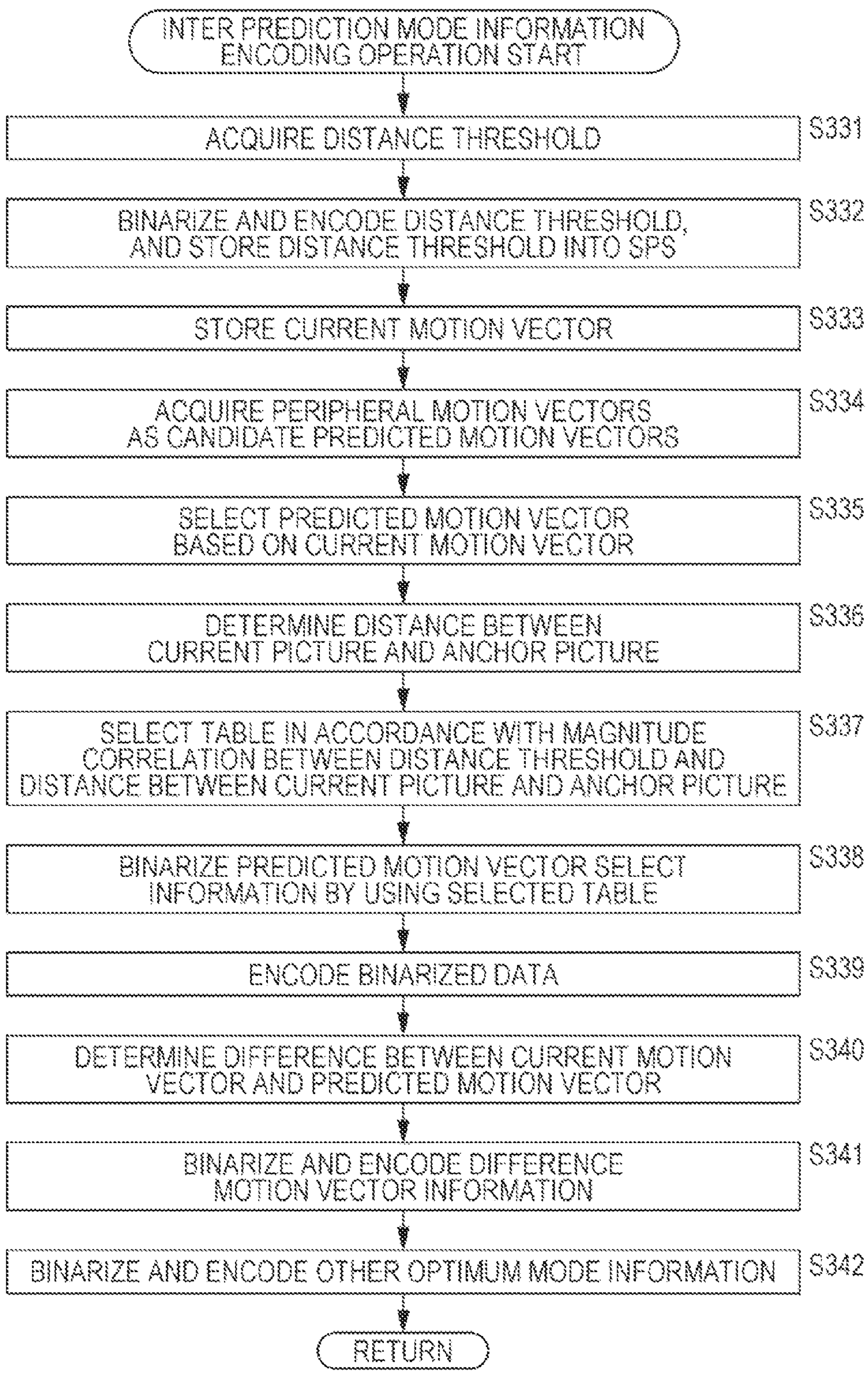

INTER PREDICTION MODE INFORMATION ENCODING OPERATION START
ACQUIRE DISTANCE THRESHOLD
S331
BINARIZE AND ENCODE DISTANCE THRESHOLD, AND STORE DISTANCE THRESHOLD INTO SPS
S332
STORE CURRENT MOTION VECTOR
S333
ACQUIRE PERIPHERAL MOTION VECTORS AS CANDIDATE PREDICTED MOTION VECTORS
S334
SELECT PREDICTED MOTION VECTOR BASED ON CURRENT MOTION VECTOR
S335
DETERMINE DISTANCE BETWEEN CURRENT PICTURE AND ANCHOR PICTURE
S336
SELECT TABLE IN ACCORDANCE WITH MAGNITUDE CORRELATION BETWEEN DISTANCE THRESHOLD AND DISTANCE BETWEEN CURRENT PICTURE AND ANCHOR PICTURE
S337
BINARIZE PREDICTED MOTION VECTOR SELECT INFORMATION BY USING SELECTED TABLE
S338
ENCODE BINARIZED DATA
S339
DETERMINE DIFFERENCE BETWEEN CURRENT MOTION VECTOR AND PREDICTED MOTION VECTOR
S340
BINARIZE AND ENCODE DIFFERENCE MOTION VECTOR INFORMATION
S341
BINARIZE AND ENCODE OTHER OPTIMUM MODE INFORMATION
S342
RETURN

FIG. 19

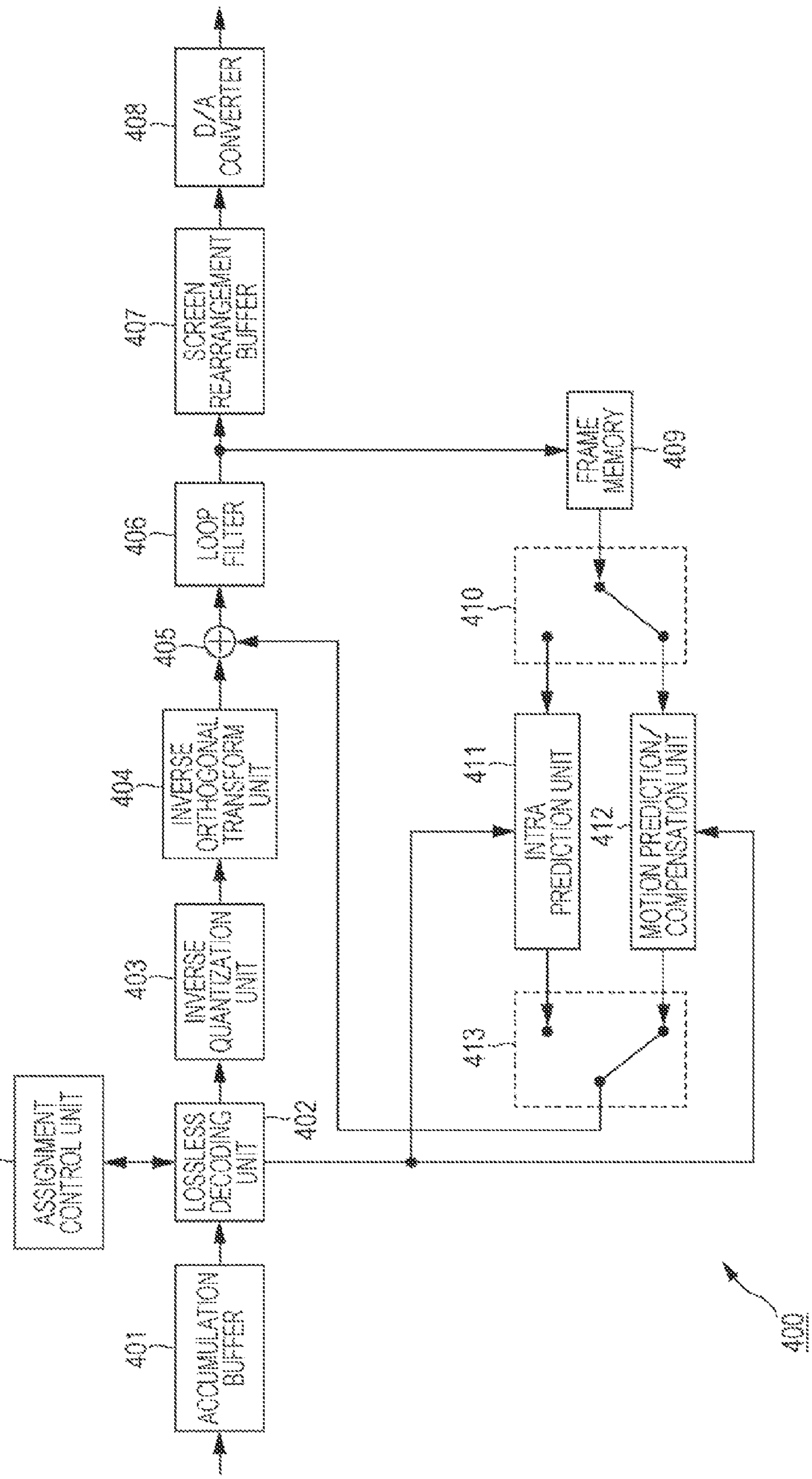
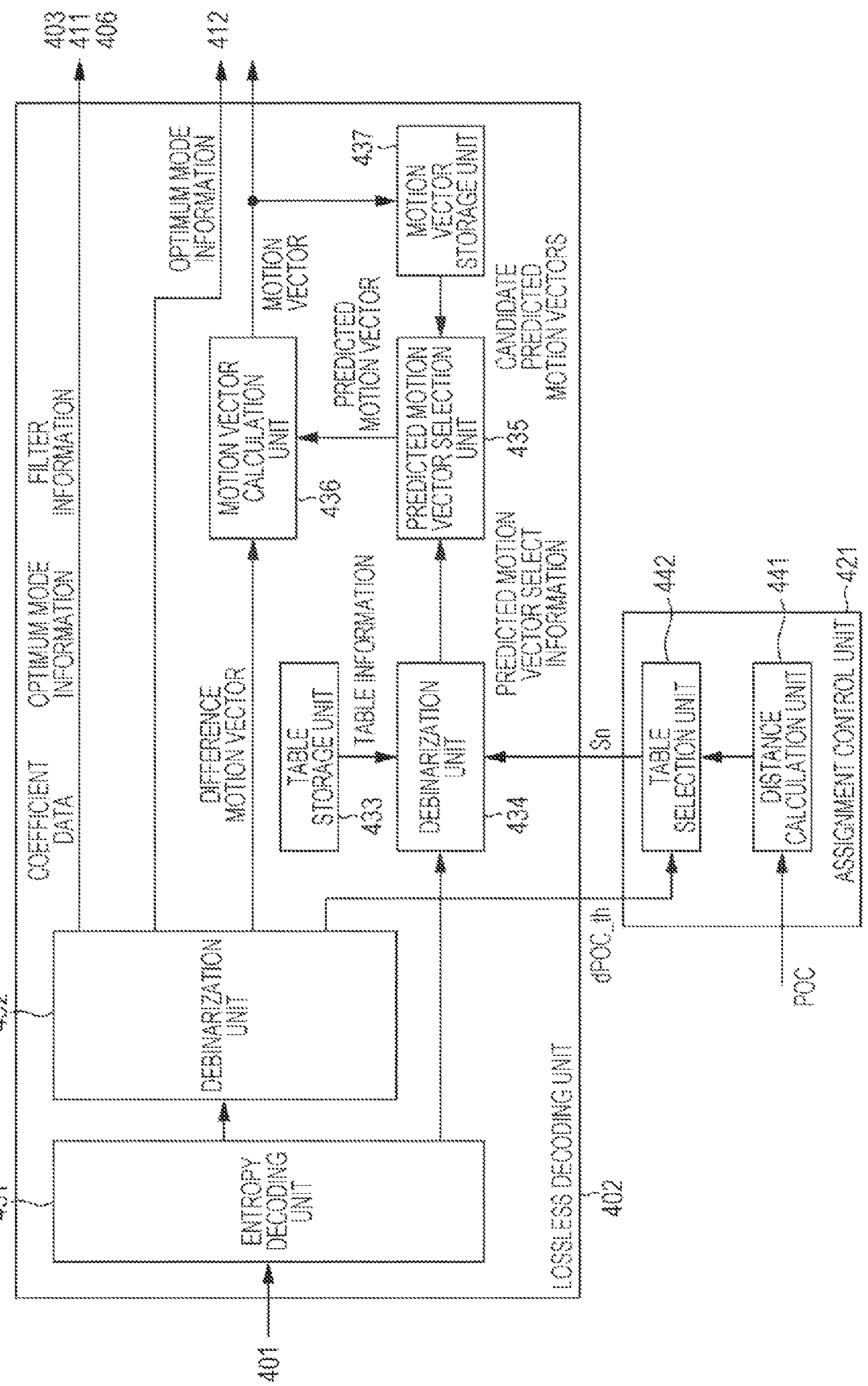
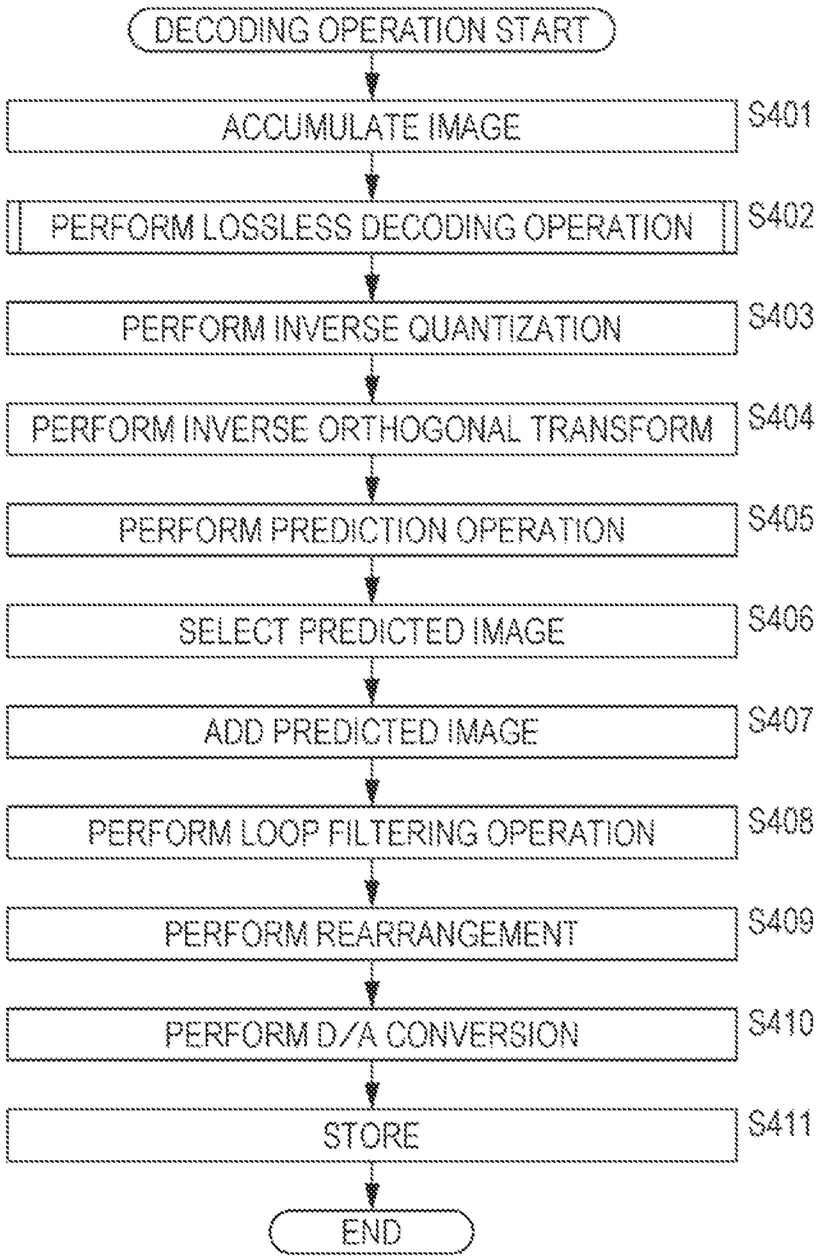

ACCUMULATION BUFFER
401
LOSSLESS DECODING UNIT
402
ASSIGNMENT CONTROL UNIT
421
INVERSE QUANTIZATION UNIT
403
INVERSE ORTHOGONAL TRANSFORM UNIT
404
405
LOOP FILTER
406
SCREEN REARRANGEMENT BUFFER
407
D/A CONVERTER
408
FRAME MEMORY
409
410
INTRA PREDICTION UNIT
411
MOTION PREDICTION/ COMPENSATION UNIT
412
413
400

FIG. 20



401
431
ENTROPY DECODING UNIT
432
DEBINARIZATION UNIT
LOSSLESS DECODING UNIT
402
COEFFICENT DATA
OPTIMUM MODE INFORMATION
FILTER INFORMATION
403
411
406
412
OPTIMUM MODE INFORMATION
DIFFERENCE MOTION VECTOR
MOTION VECTOR CALCULATION UNIT
436
MOTION VECTOR
TABLE STORAGE UNIT
433
TABLE INFORMATION
DEBINARIZATION UNIT
434
PREDICTED MOTION VECTOR SELECT INFORMATION
PREDICTED MOTION VECTOR SELECTION UNIT
435
PREDICTED MOTION VECTOR
CANDIDATE PREDICTED MOTION VECTORS
MOTION VECTOR STORAGE UNIT
437
Sn
TABLE SELECTION UNIT
442
DISTANCE CALCULATION UNIT
441
ASSIGNMENT CONTROL UNIT
421
dPOC_th
POC

FIG. 21



DECODING OPERATION START
ACCUMULATE IMAGE
S401
PERFORM LOSSLESS DECODING OPERATION
S402
PERFORM INVERSE QUANTIZATION
S403
PERFORM INVERSE ORTHOGONAL TRANSFORM
S404
PERFORM PREDICTION OPERATION
S405
SELECT PREDICTED IMAGE
S406
ADD PREDICTED IMAGE
S407
PERFORM LOOP FILTERING OPERATION
S408
PERFORM REARRANGEMENT
S409
PERFORM D/A CONVERSION
S410
STORE
S411
END

FIG. 22

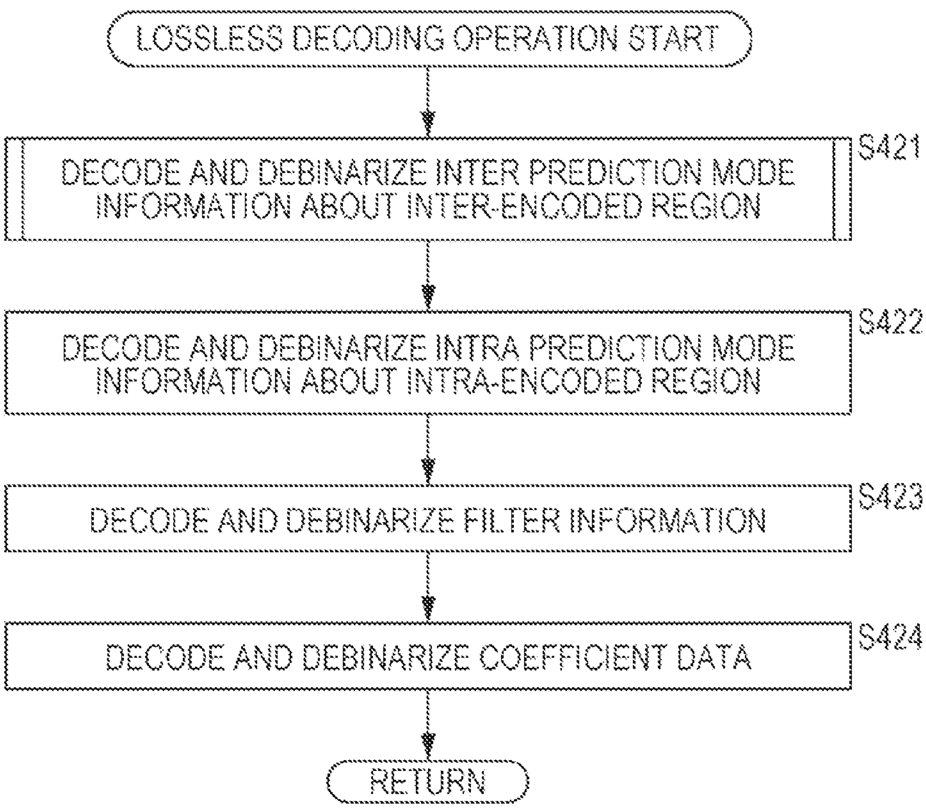

LOSSLESS DECODING OPERATION START
S421
DECODE AND DEBINARIZE INTER PREDICTION MODE INFORMATION ABOUT INTER-ENCODED REGION
S422
DECODE AND DEBINARIZE INTRA PREDICTION MODE INFORMATION ABOUT INTRA-ENCODED REGION
S423
DECODE AND DEBINARIZE FILTER INFORMATION
S424
DECODE AND DEBINARIZE COEFFICIENT DATA
RETURN

FIG. 23

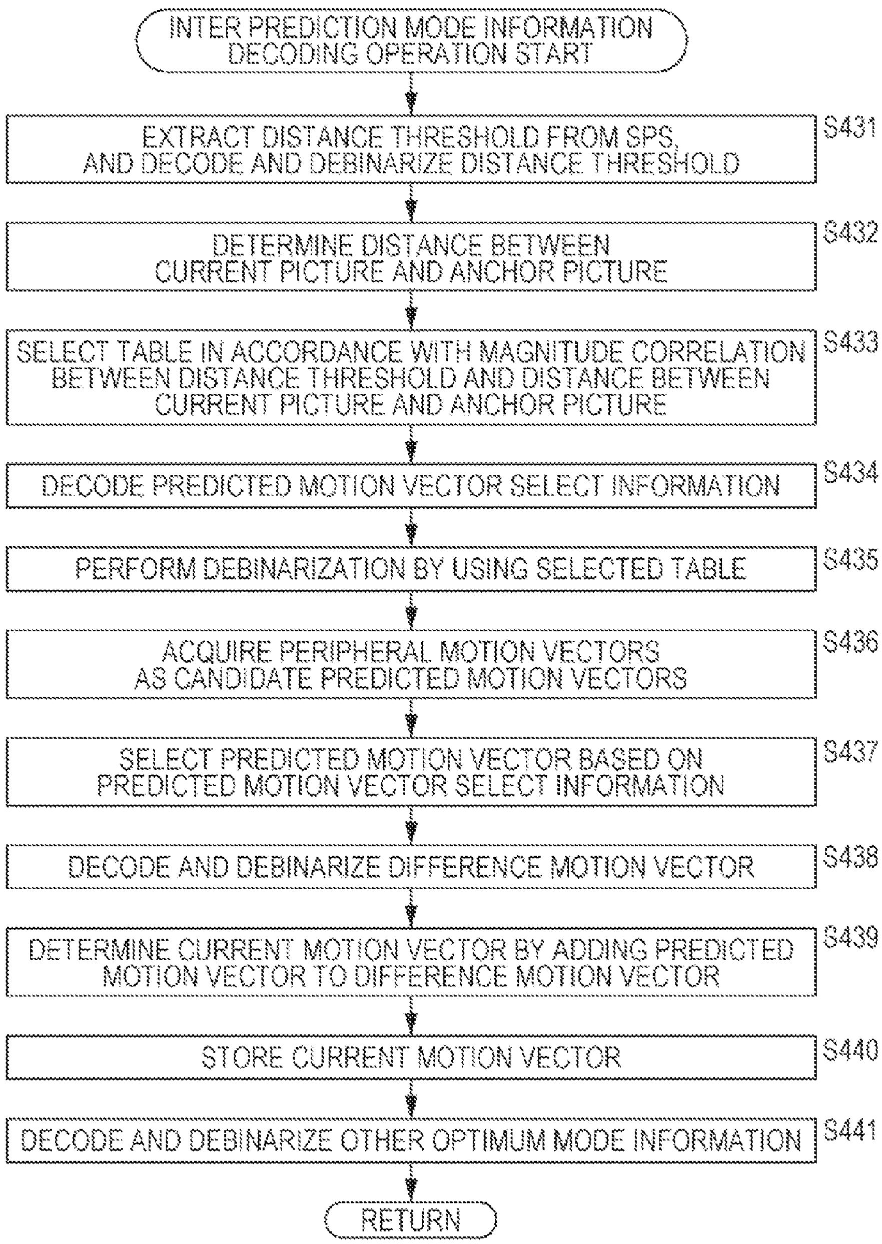

INTER PREDICTION MODE INFORMATION DECODING OPERATION START
EXTRACT DISTANCE THRESHOLD FROM SPS, AND DECODE AND DEBINARIZE DISTANCE THRESHOLD
S431
DETERMINE DISTANCE BETWEEN CURRENT PICTURE AND ANCHOR PICTURE
S432
SELECT TABLE IN ACCORDANCE WITH MAGNITUDE CORRELATION BETWEEN DISTANCE THRESHOLD AND DISTANCE BETWEEN CURRENT PICTURE AND ANCHOR PICTURE
S433
DECODE PREDICTED MOTION VECTOR SELECT INFORMATION
S434
PERFORM DEBINARIZATION BY USING SELECTED TABLE
S435
ACQUIRE PERIPHERAL MOTION VECTORS AS CANDIDATE PREDICTED MOTION VECTORS
S436
SELECT PREDICTED MOTION VECTOR BASED ON PREDICTED MOTION VECTOR SELECT INFORMATION
S437
DECODE AND DEBINARIZE DIFFERENCE MOTION VECTOR
S438
DETERMINE CURRENT MOTION VECTOR BY ADDING PREDICTED MOTION VECTOR TO DIFFERENCE MOTION VECTOR
S439
STORE CURRENT MOTION VECTOR
S440
DECODE AND DEBINARIZE OTHER OPTIMUM MODE INFORMATION
S441
RETURN

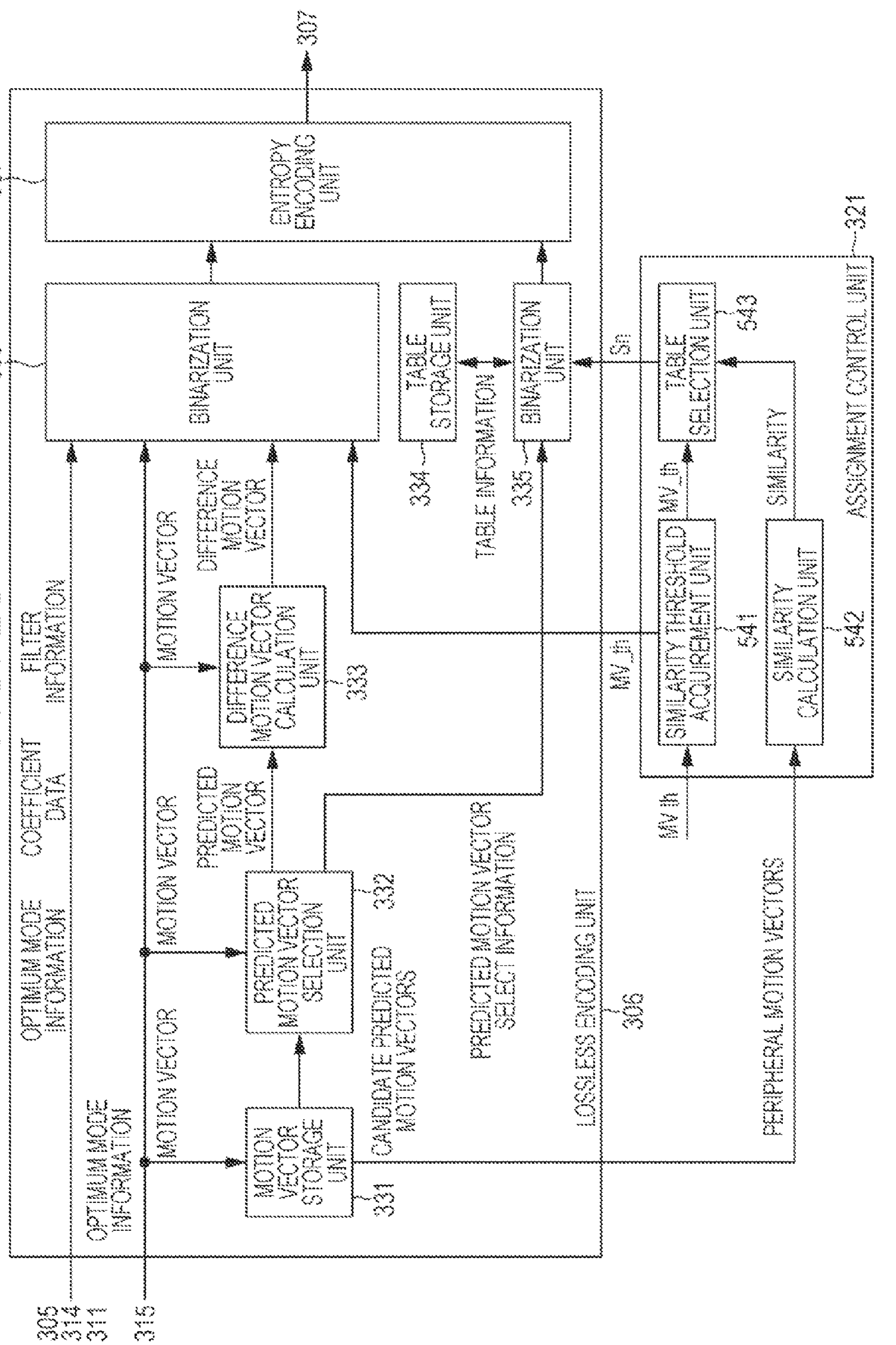
FIG. 24

CODE NUMBER	BIT SEQUENCE	S1	S3
0	1	Median	MV_Tmp
1	010	MV_A	MV_A
2	011	MV_B	MV_B
3	00100	MV_C	MV_C
4	00101	MV_E	MV_E
5	00110	MV_D	MV_D
6	00111	MV_Tmp	Median

FIG. 25

CODE NUMBER	BIT SEQUENCE	S1	S2
0	1	Median	MV_Tmp
1	10	MV_A	Median
2	110	MV_B	MV_A
3	1110	MV_C	MV_B
4	11110	MV_E	MV_C
5	111110	MV_D	MV_E
6	111111	MV_Tmp	MV_D

FIG. 26



305
314
311
315
OPTIMUM MODE INFORMATION
COEFFICIENT DATA
FILTER INFORMATION
OPTIMUM MODE INFORMATION
MOTION VECTOR
MOTION VECTOR
MOTION VECTOR
MOTION VECTOR
MOTION VECTOR STORAGE UNIT
331
CANDIDATE PREDICTED MOTION VECTORS
PREDICTED MOTION VECTOR SELECTION UNIT
332
PREDICTED MOTION VECTOR
DIFFERENCE MOTION VECTOR CALCULATION UNIT
333
DIFFERENCE MOTION VECTOR
BINARIZATION UNIT
336
ENTROPY ENCODING UNIT
337
307
TABLE STORAGE UNIT
334
TABLE INFORMATION
BINARIZATION UNIT
335
PREDICTED MOTION VECTOR SELECT INFORMATION
LOSSLESS ENCODING UNIT
306
MV_th
Sn
MV th
SIMILARITY THRESHOLD ACQUIREMENT UNIT
541
MV_th
TABLE SELECTION UNIT
543
SIMILARITY CALCULATION UNIT
542
SIMILARITY
PERIPHERAL MOTION VECTORS
ASSIGNMENT CONTROL UNIT
321

FIG. 27

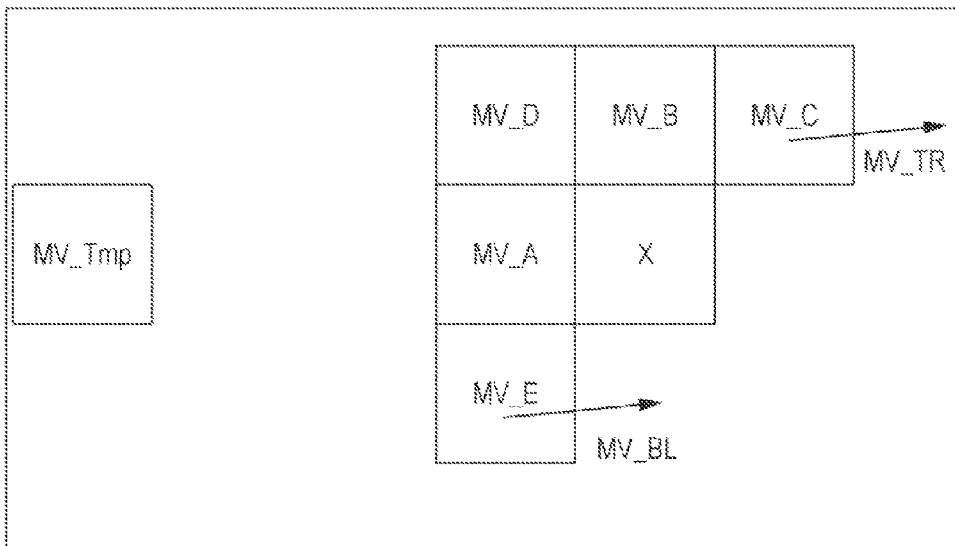

MV_D
MV_B
MV_C
MV_TR
MV_Tmp
MV_A
X
MV_E
MV_BL

FIG. 28

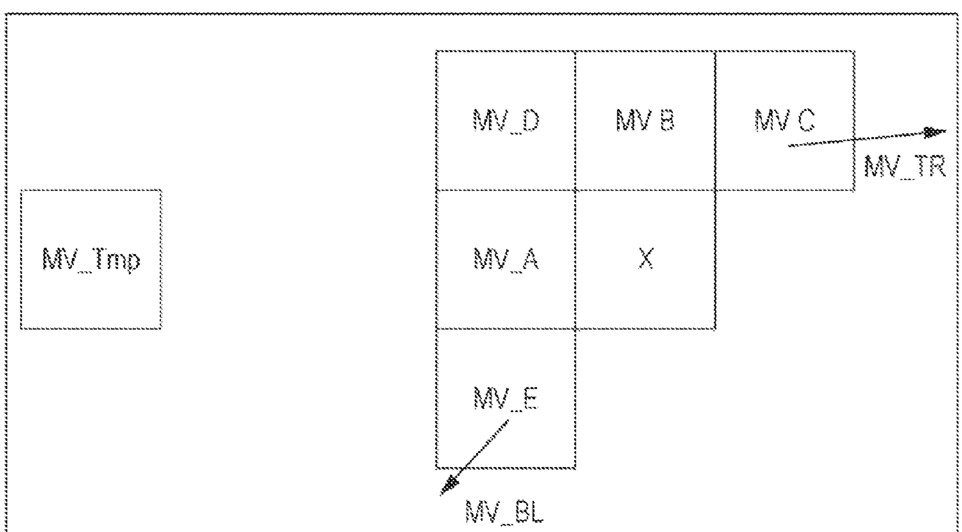

MV_D
MV B
MV C
MV_TR
MV_Tmp
MV_A
X
MV_E
MV_BL

FIG. 29

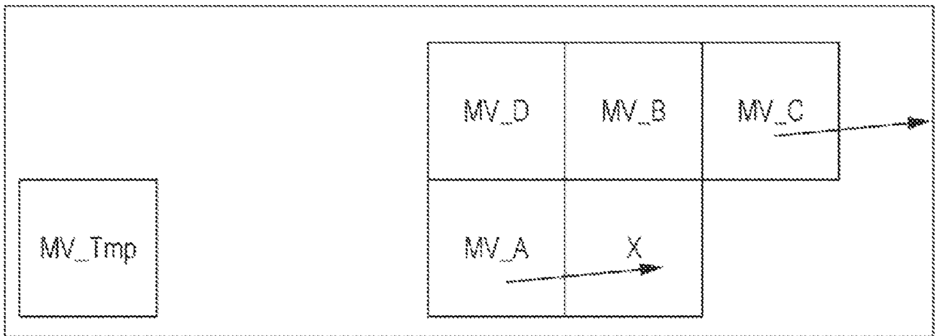


FIG. 30

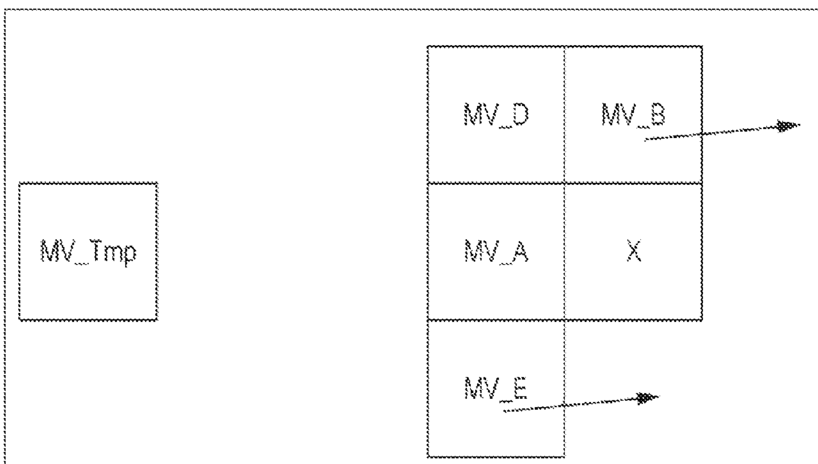


FIG. 31

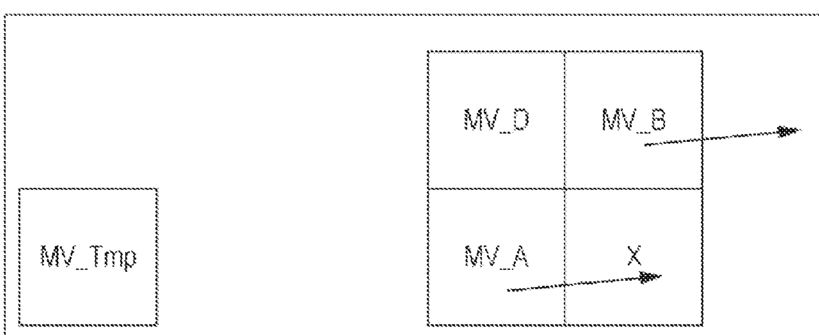


FIG. 32

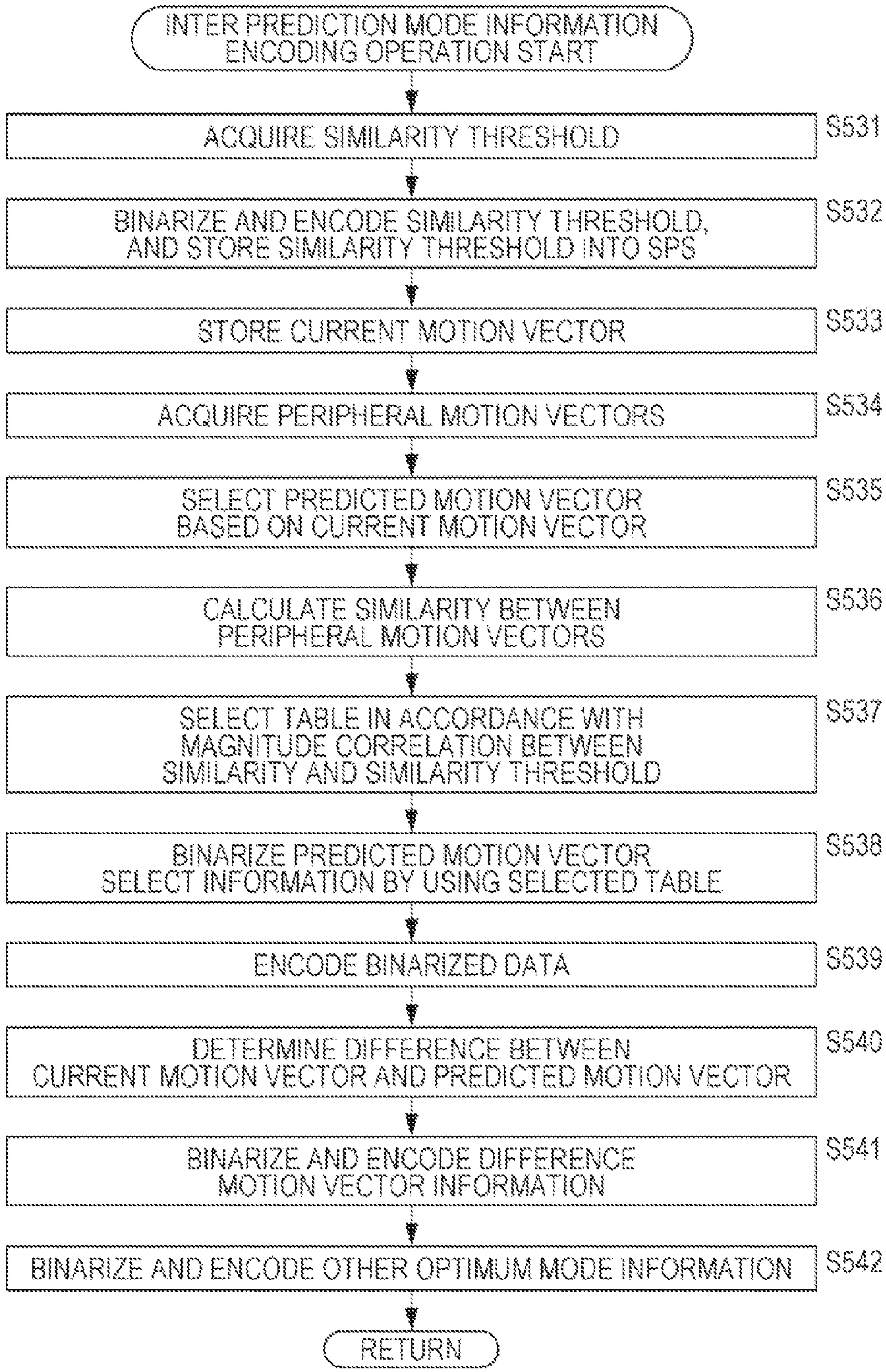

INTER PREDICTION MODE INFORMATION ENCODING OPERATION START
ACQUIRE SIMILARITY THRESHOLD
S531
BINARIZE AND ENCODE SIMILARITY THRESHOLD, AND STORE SIMILARITY THRESHOLD INTO SPS
S532
STORE CURRENT MOTION VECTOR
S533
ACQUIRE PERIPHERAL MOTION VECTORS
S534
SELECT PREDICTED MOTION VECTOR BASED ON CURRENT MOTION VECTOR
S535
CALCULATE SIMILARITY BETWEEN PERIPHERAL MOTION VECTORS
S536
SELECT TABLE IN ACCORDANCE WITH MAGNITUDE CORRELATION BETWEEN SIMILARITY AND SIMILARITY THRESHOLD
S537
BINARIZE PREDICTED MOTION VECTOR SELECT INFORMATION BY USING SELECTED TABLE
S538
ENCODE BINARIZED DATA
S539
DETERMINE DIFFERENCE BETWEEN CURRENT MOTION VECTOR AND PREDICTED MOTION VECTOR
S540
BINARIZE AND ENCODE DIFFERENCE MOTION VECTOR INFORMATION
S541
BINARIZE AND ENCODE OTHER OPTIMUM MODE INFORMATION
S542
RETURN

FIG. 33

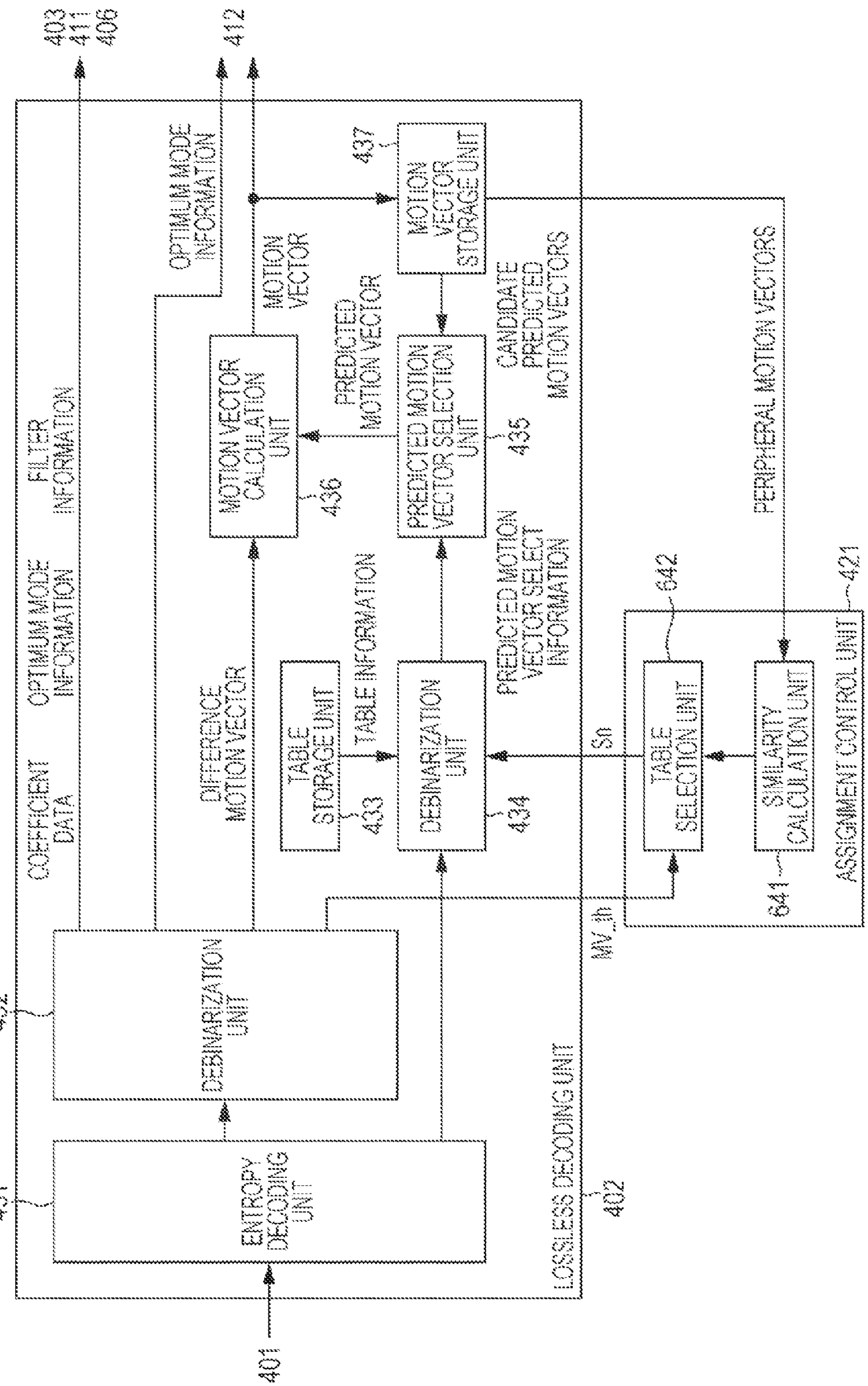
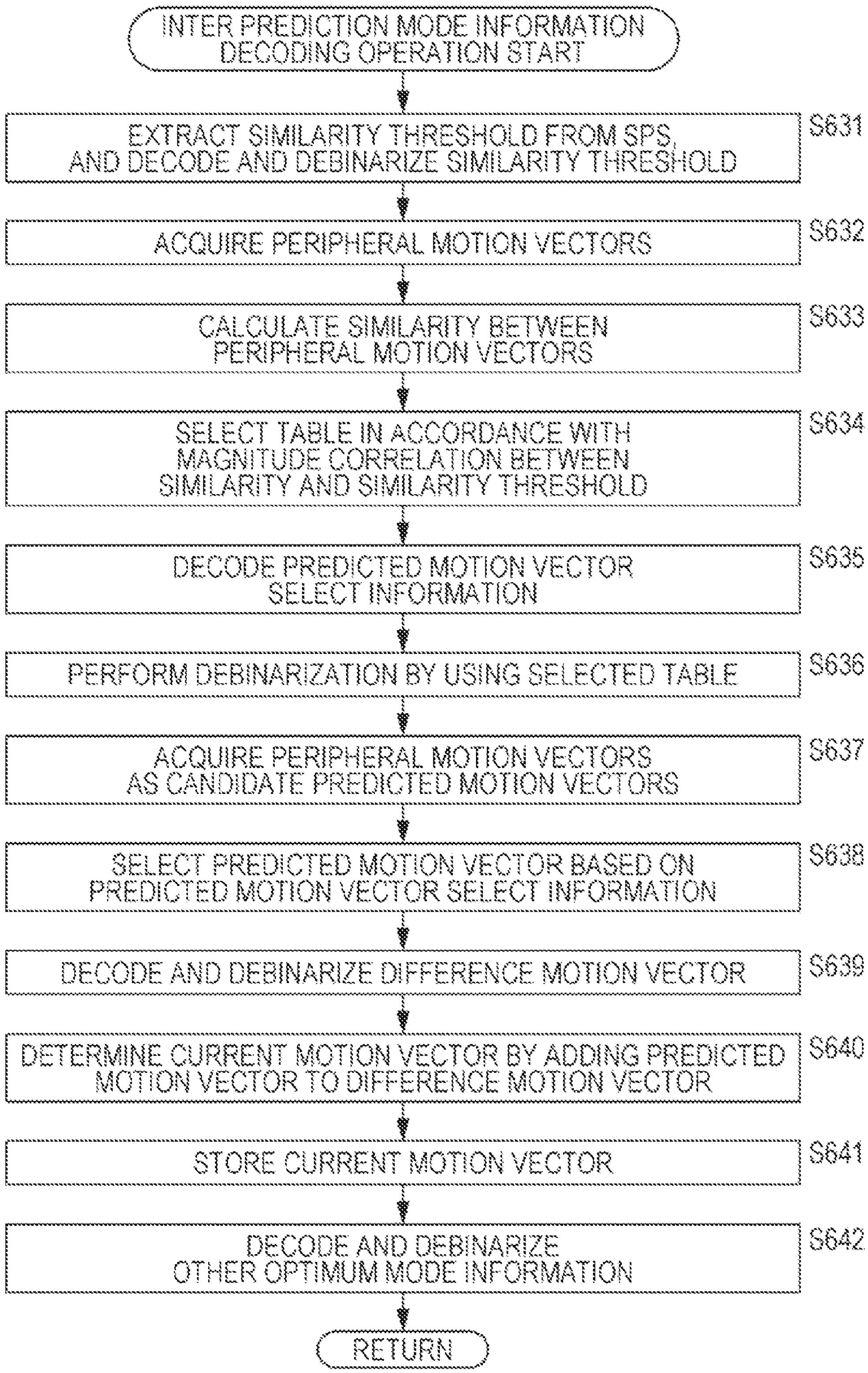

401
ENTROPY DECODING UNIT
431
DEBINARIZATION UNIT
432
COEFFICIENT DATA
OPTIMUM MODE INFORMATION
FILTER INFORMATION
403
411
406
OPTIMUM MODE INFORMATION
412
DIFFERENCE MOTION VECTOR
MOTION VECTOR CALCULATION UNIT
436
MOTION VECTOR
TABLE STORAGE UNIT
433
TABLE INFORMATION
DEBINARIZATION UNIT
434
PREDICTED MOTION VECTOR SELECT INFORMATION
PREDICTED MOTION VECTOR SELECTION UNIT
435
PREDICTED MOTION VECTOR
CANDIDATE PREDICTED MOTION VECTORS
MOTION VECTOR STORAGE UNIT
437
PERIPHERAL MOTION VECTORS
MV_th
Sn
TABLE SELECTION UNIT
642
SIMILARITY CALCULATION UNIT
641
ASSIGNMENT CONTROL UNIT
421
LOSSLESS DECODING UNIT
402

FIG. 34


INTER PREDICTION MODE INFORMATION DECODING OPERATION START
EXTRACT SIMILARITY THRESHOLD FROM SPS, AND DECODE AND DEBINARIZE SIMILARITY THRESHOLD
S631
ACQUIRE PERIPHERAL MOTION VECTORS
S632
CALCULATE SIMILARITY BETWEEN PERIPHERAL MOTION VECTORS
S633
SELECT TABLE IN ACCORDANCE WITH MAGNITUDE CORRELATION BETWEEN SIMILARITY AND SIMILARITY THRESHOLD
S634
DECODE PREDICTED MOTION VECTOR SELECT INFORMATION
S635
PERFORM DEBINARIZATION BY USING SELECTED TABLE
S636
ACQUIRE PERIPHERAL MOTION VECTORS AS CANDIDATE PREDICTED MOTION VECTORS
S637
SELECT PREDICTED MOTION VECTOR BASED ON PREDICTED MOTION VECTOR SELECT INFORMATION
S638
DECODE AND DEBINARIZE DIFFERENCE MOTION VECTOR
S639
DETERMINE CURRENT MOTION VECTOR BY ADDING PREDICTED MOTION VECTOR TO DIFFERENCE MOTION VECTOR
S640
STORE CURRENT MOTION VECTOR
S641
DECODE AND DEBINARIZE OTHER OPTIMUM MODE INFORMATION
S642
RETURN

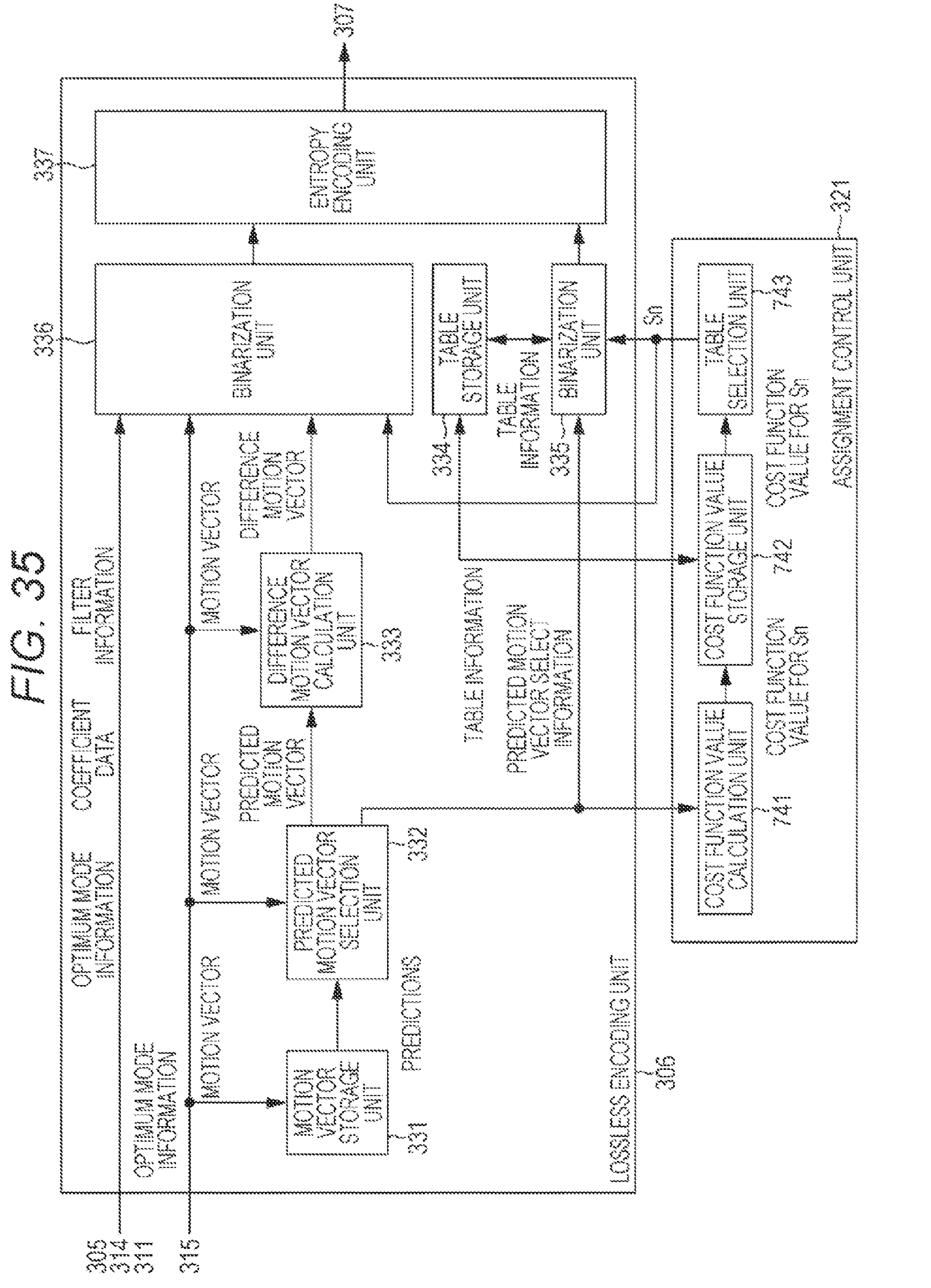

307
337
ENTROPY ENCODING UNIT
336
BINARIZATION UNIT
TABLE STORAGE UNIT
334
TABLE INFORMATION
BINARIZATION UNIT
335
Sn
321
TABLE SELECTION UNIT
743
COST FUNCTION VALUE FOR Sn
ASSIGNMENT CONTROL UNIT
COST FUNCTION VALUE STORAGE UNIT
742
COST FUNCTION VALUE FOR Sn
COST FUNCTION VALUE CALCULATION UNIT
741
OPTIMUM MODE INFORMATION
COEFFICIENT DATA
FILTER INFORMATION
MOTION VECTOR
DIFFERENCE MOTION VECTOR
DIFFERENCE MOTION VECTOR CALCULATION UNIT
333
PREDICTED MOTION VECTOR
TABLE INFORMATION
PREDICTED MOTION VECTOR SELECT INFORMATION
PREDICTED MOTION VECTOR SELECTION UNIT
332
PREDICTIONS
MOTION VECTOR STORAGE UNIT
331
LOSSLESS ENCODING UNIT
306
305
314
311
315

FIG. 35

FIG. 36

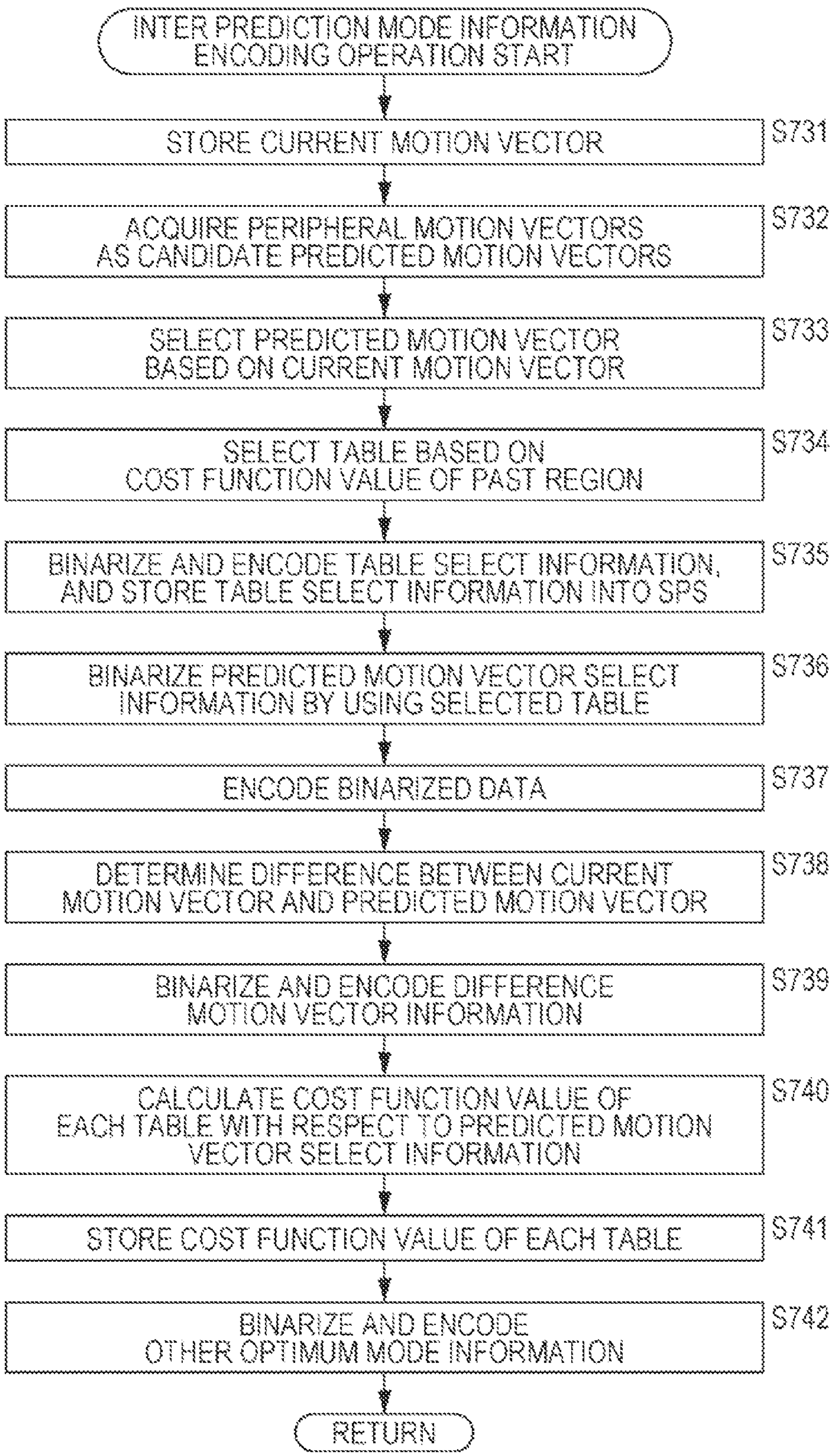

INTER PREDICTION MODE INFORMATION ENCODING OPERATION START
STORE CURRENT MOTION VECTOR
S731
ACQUIRE PERIPHERAL MOTION VECTORS AS CANDIDATE PREDICTED MOTION VECTORS
S732
SELECT PREDICTED MOTION VECTOR BASED ON CURRENT MOTION VECTOR
S733
SELECT TABLE BASED ON COST FUNCTION VALUE OF PAST REGION
S734
BINARIZE AND ENCODE TABLE SELECT INFORMATION, AND STORE TABLE SELECT INFORMATION INTO SPS
S735
BINARIZE PREDICTED MOTION VECTOR SELECT INFORMATION BY USING SELECTED TABLE
S736
ENCODE BINARIZED DATA
S737
DETERMINE DIFFERENCE BETWEEN CURRENT MOTION VECTOR AND PREDICTED MOTION VECTOR
S738
BINARIZE AND ENCODE DIFFERENCE MOTION VECTOR INFORMATION
S739
CALCULATE COST FUNCTION VALUE OF EACH TABLE WITH RESPECT TO PREDICTED MOTION VECTOR SELECT INFORMATION
S740
STORE COST FUNCTION VALUE OF EACH TABLE
S741
BINARIZE AND ENCODE OTHER OPTIMUM MODE INFORMATION
S742
RETURN

FIG. 37

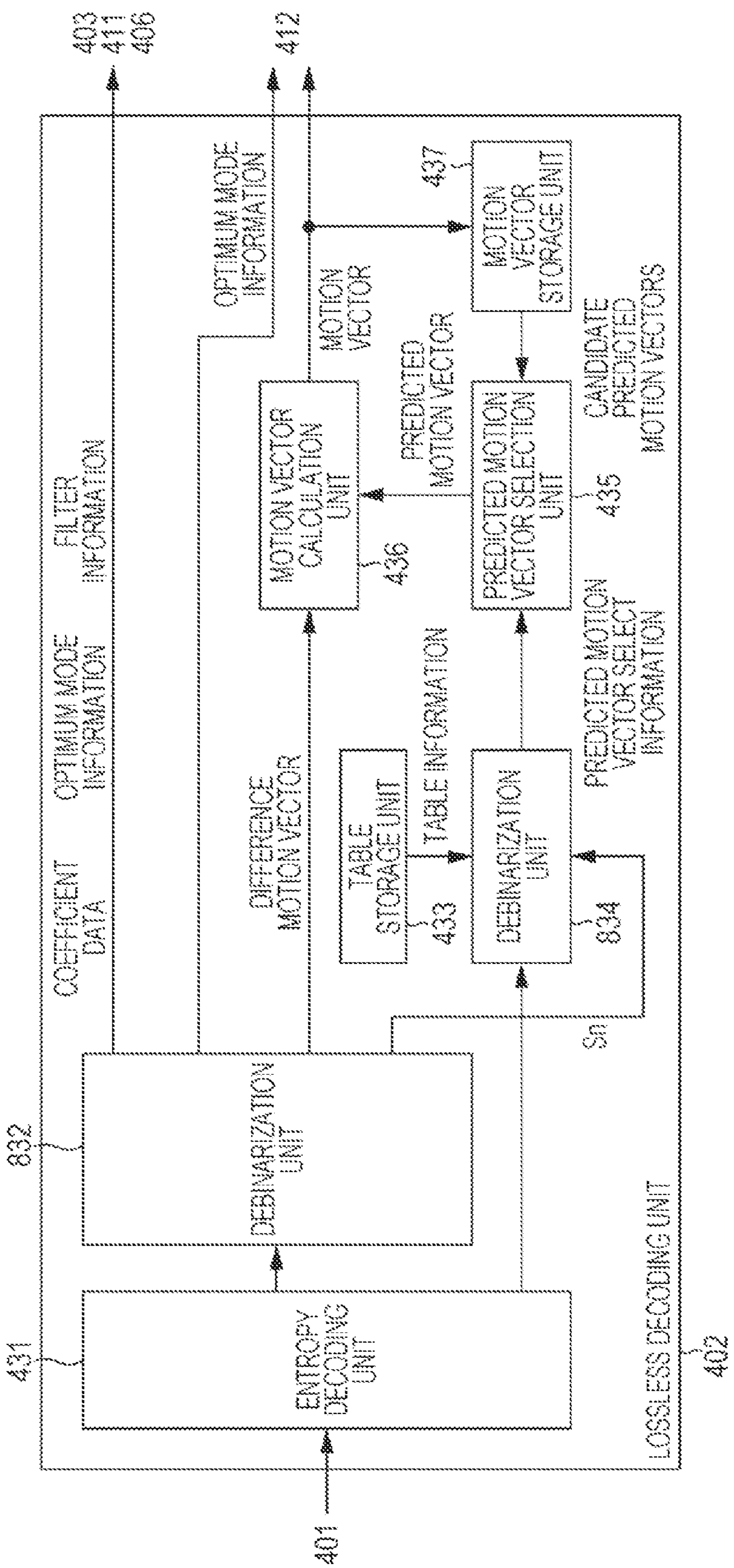

403
411
406
412
OPTIMUM MODE INFORMATION
MOTION VECTOR
437
MOTION VECTOR STORAGE UNIT
PREDICTED MOTION VECTOR
CANDIDATE PREDICTED MOTION VECTORS
MOTION VECTOR CALCULATION UNIT
436
PREDICTED MOTION VECTOR SELECTION UNIT
435
FILTER INFORMATION
OPTIMUM MODE INFORMATION
COEFFICIENT DATA
DIFFERENCE MOTION VECTOR
TABLE STORAGE UNIT
433
TABLE INFORMATION
DEBINARIZATION UNIT
834
PREDICTED MOTION VECTOR SELECT INFORMATION
Sn
832
DEBINARIZATION UNIT
431
ENTROPY DECODING UNIT
LOSSLESS DECODING UNIT
402
401

FIG. 38

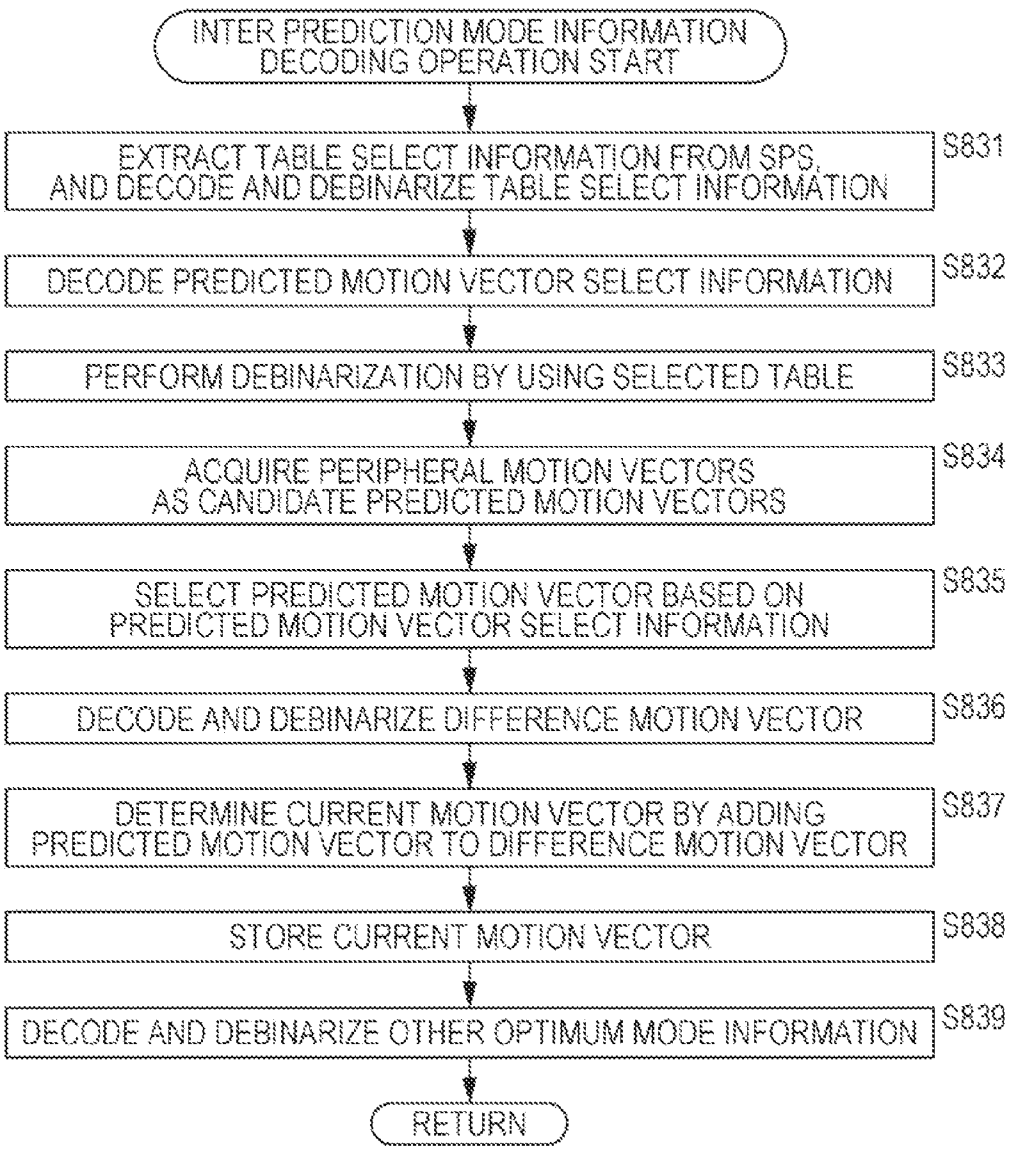

INTER PREDICTION MODE INFORMATION DECODING OPERATION START
EXTRACT TABLE SELECT INFORMATION FROM SPS, AND DECODE AND DEBINARIZE TABLE SELECT INFORMATION
S831
DECODE PREDICTED MOTION VECTOR SELECT INFORMATION
S832
PERFORM DEBINARIZATION BY USING SELECTED TABLE
S833
ACQUIRE PERIPHERAL MOTION VECTORS AS CANDIDATE PREDICTED MOTION VECTORS
S834
SELECT PREDICTED MOTION VECTOR BASED ON PREDICTED MOTION VECTOR SELECT INFORMATION
S835
DECODE AND DEBINARIZE DIFFERENCE MOTION VECTOR
S836
DETERMINE CURRENT MOTION VECTOR BY ADDING PREDICTED MOTION VECTOR TO DIFFERENCE MOTION VECTOR
S837
STORE CURRENT MOTION VECTOR
S838
DECODE AND DEBINARIZE OTHER OPTIMUM MODE INFORMATION
S839
RETURN

FIG. 39

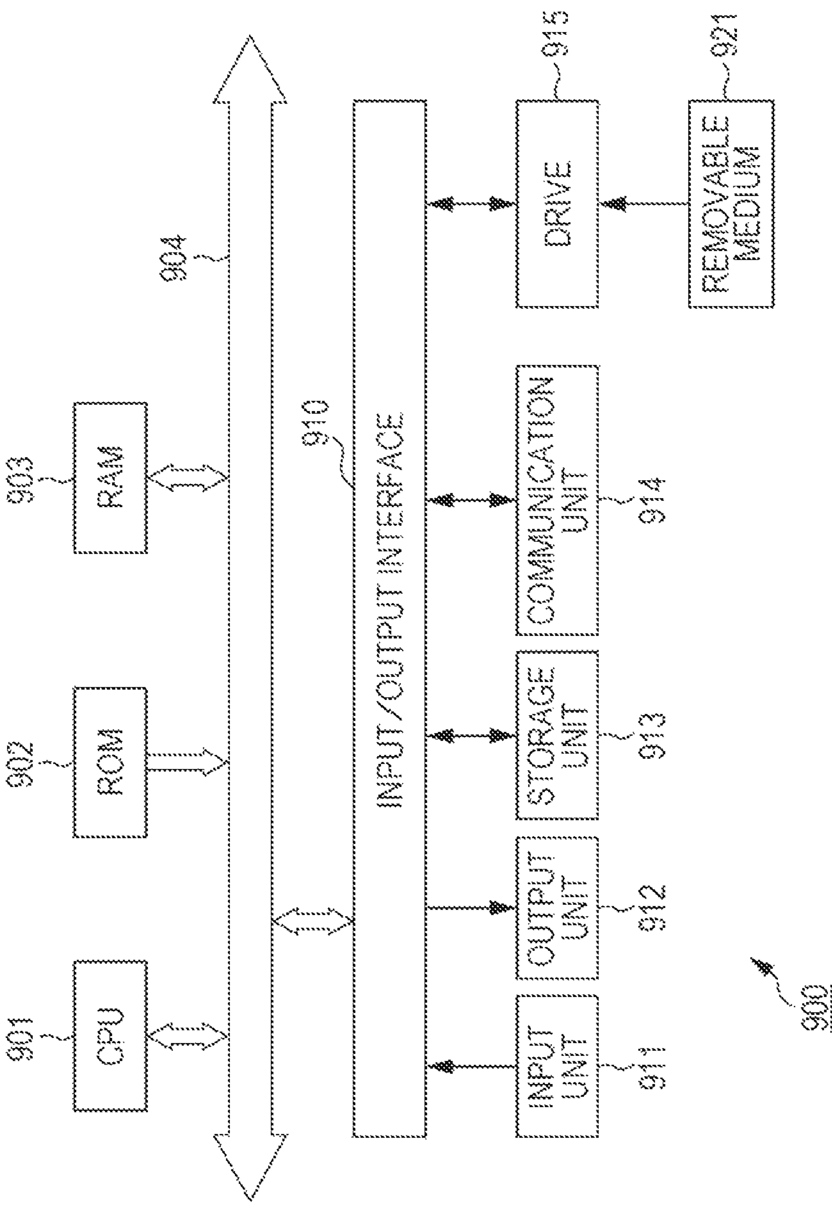
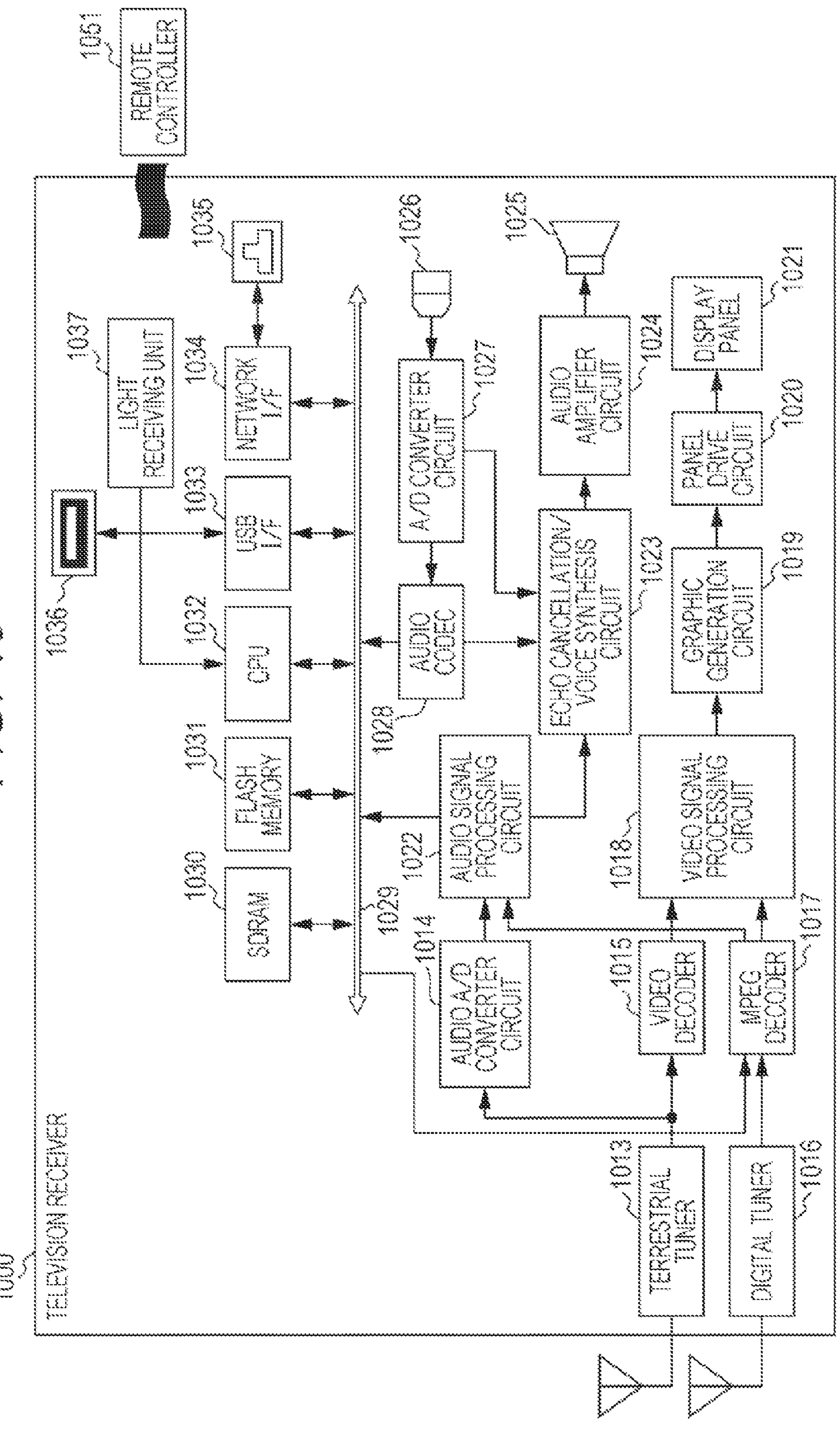

CPU
ROM
RAM
INPUT/OUTPUT INTERFACE
INPUT UNIT
OUTPUT UNIT
STORAGE UNIT
COMMUNICATION UNIT
DRIVE
REMOVABLE MEDIUM
901
902
903
904
910
911
912
913
914
915
921
900

FIG. 40



1000
TELEVISION RECEIVER
1013
TERRESTRIAL TUNER
1016
DIGITAL TUNER
1014
AUDIO A/D CONVERTER CIRCUIT
1015
VIDEO DECODER
1017
MPEG DECODER
1018
VIDEO SIGNAL PROCESSING CIRCUIT
1019
GRAPHIC GENERATION CIRCUIT
1020
PANEL DRIVE CIRCUIT
1021
DISPLAY PANEL
1022
AUDIO SIGNAL PROCESSING CIRCUIT
1023
ECHO CANCELLATION/ VOICE SYNTHESIS CIRCUIT
1024
AUDIO AMPLIFIER CIRCUIT
1025
1026
1027
A/D CONVERTER CIRCUIT
1028
AUDIO CODEC
1029
1030
SDRAM
1031
FLASH MEMORY
1032
CPU
1033
USB I/F
1034
NETWORK I/F
1035
1036
1037
LIGHT RECEIVING UNIT
1051
REMOTE CONTROLLER

FIG. 41

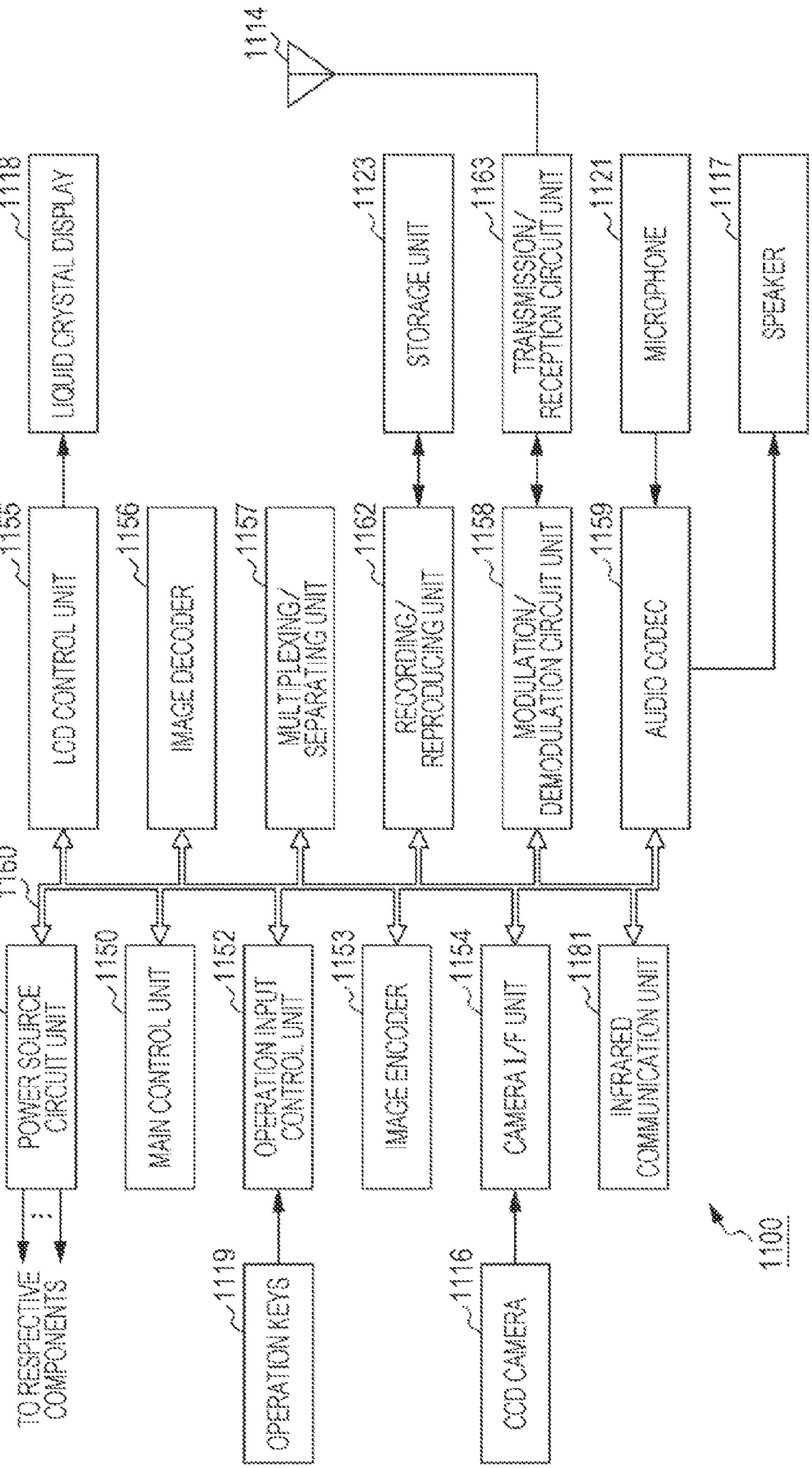

1114
1118
LIQUID CRYSTAL DISPLAY
1123
STORAGE UNIT
1163
TRANSMISSION/ RECEPTION CIRCUIT UNIT
1121
MICROPHONE
1117
SPEAKER
1155
LCD CONTROL UNIT
1156
IMAGE DECODER
1157
MULTIPLEXING/ SEPARATING UNIT
1162
RECORDING/ REPRODUCING UNIT
1158
MODULATION/ DEMODULATION CIRCUIT UNIT
1159
AUDIO CODEC
1160
1151
POWER SOURCE CIRCUIT UNIT
1150
MAIN CONTROL UNIT
1152
OPERATION INPUT CONTROL UNIT
1153
IMAGE ENCODER
1154
CAMERA I/F UNIT
1181
INFRARED COMMUNICATION UNIT
TO RESPECTIVE COMPONENTS
1119
OPERATION KEYS
1116
CCD CAMERA
1100

FIG. 42

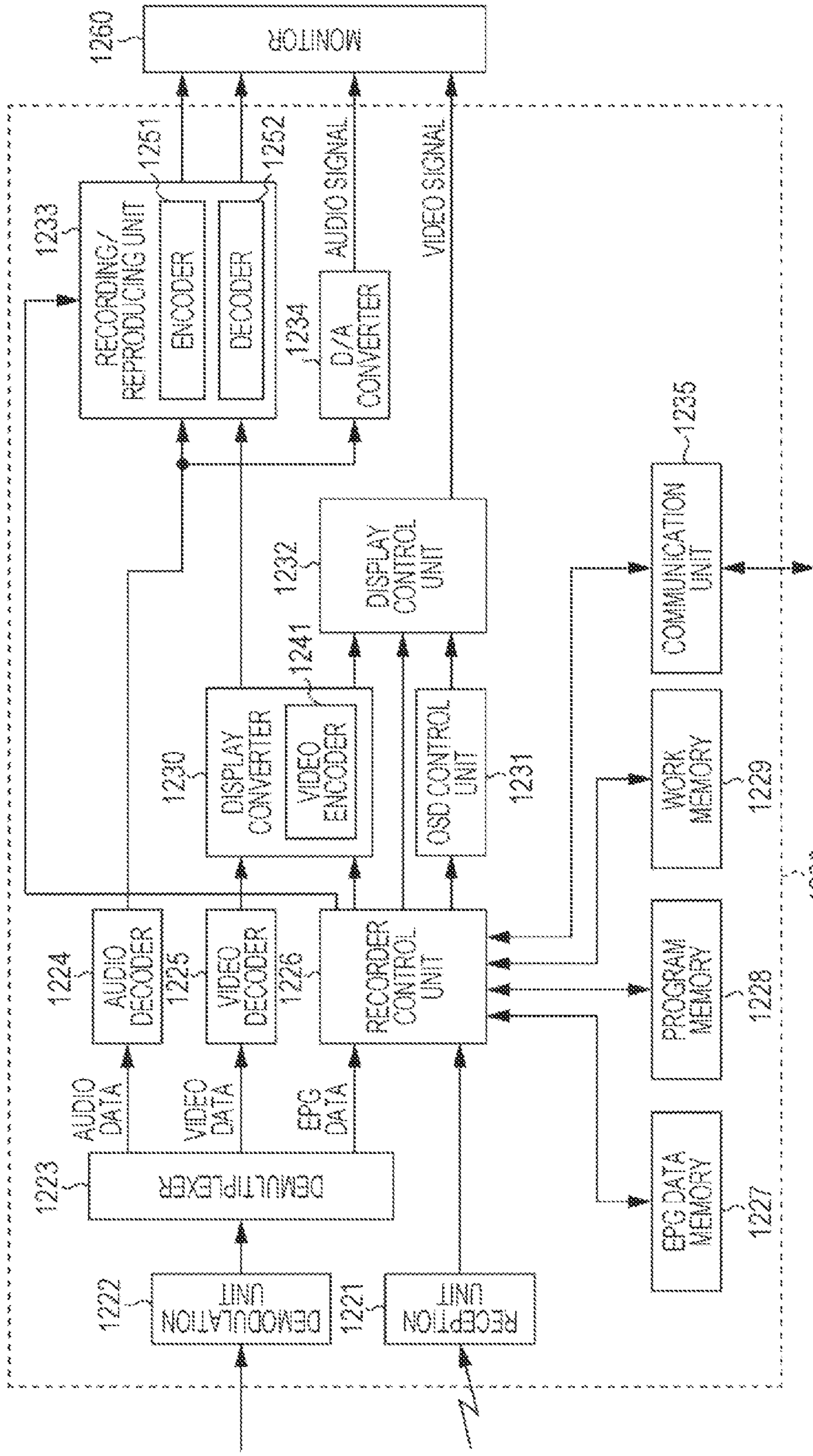

MONITOR
1260
1200
RECEPTION UNIT
1221
DEMODULATION UNIT
1222
DEMULTIPLEXER
1223
AUDIO DATA
VIDEO DATA
EPG DATA
AUDIO DECODER
1224
VIDEO DECODER
1225
RECORDER CONTROL UNIT
1226
EPG DATA MEMORY
1227
PROGRAM MEMORY
1228
WORK MEMORY
1229
DISPLAY CONVERTER
1230
VIDEO ENCODER
1241
OSD CONTROL UNIT
1231
DISPLAY CONTROL UNIT
1232
RECORDING/ REPRODUCING UNIT
1233
ENCODER
1251
DECODER
1252
D/A CONVERTER
1234
COMMUNICATION UNIT
1235
AUDIO SIGNAL
VIDEO SIGNAL

FIG. 43

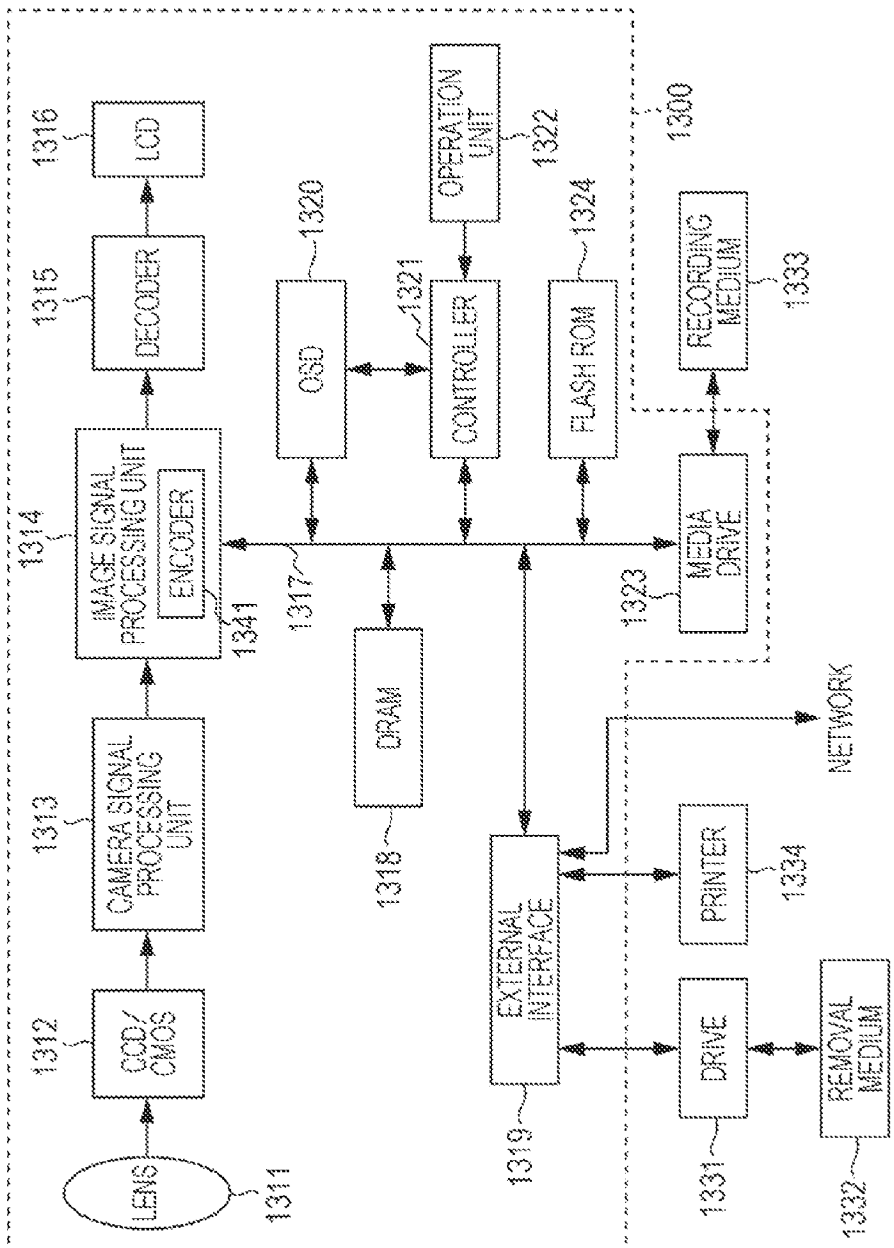

LENS
1311
CCD/CMOS
1312
CAMERA SIGNAL PROCESSING UNIT
1313
IMAGE SIGNAL PROCESSING UNIT
ENCODER
1341
1314
DECODER
1315
LCD
1316
1317
DRAM
1318
OSD
1320
CONTROLLER
1321
OPERATION UNIT
1322
FLASH ROM
1324
MEDIA DRIVE
1323
RECORDING MEDIUM
1333
1300
EXTERNAL INTERFACE
1319
PRINTER
1334
NETWORK
DRIVE
1331
REMOVAL MEDIUM
1332

IMAGE PROCESSING DEVICE AND METHOD

CROSS REFERENCE TO PRIOR APPLICATION

This application is a National Stage Patent Application of PCT International Patent Application No. PCT/JP2012/051658 (filed on Jan. 26, 2012) under 35 U.S.C. §371, which claims priority to Japanese Patent Application No. P2011-023870 (filed on Feb. 7, 2011), which are all hereby incorporated by reference in their entirety.

TECHNICAL FIELD

This disclosure relates to image processing devices and methods, and more particularly, to an image processing device and method that can increase encoding efficiency.

BACKGROUND ART

In recent years, to handle image information as digital information and achieve high-efficiency information transmission and accumulation in doing do, apparatuses compliant with a standard, such as MPEG (Moving Picture Experts Group) for compressing image information through orthogonal transforms such as discrete cosine transforms and motion compensation by using redundancy inherent to image information, have been spreading among broadcast stations to distribute information and among general households to receive information.

Particularly, MPEG2 (ISO (International Organization for Standardization)/IEC (International Electrotechnical Commission) 13818-2) is defined as a general-purpose image encoding standard, and is applicable to interlaced images and non-interlaced images, and to standard-resolution images and high-definition images. Currently, MPEG2 is used in a wide range of applications for professionals and general consumers. According to the MPEG2 compression method, a bit rate of 4 to 8 Mbps is assigned to an interlaced image having a standard resolution of 720×480 pixels, and a bit rate of 18 to 22 Mbps is assigned to an interlaced image having a high-resolution of 1,920×1,088 pixels, for example. In this manner, high compression rates and excellent image quality can be realized.

MPEG2 is designed mainly for high-quality image encoding suited for broadcasting, but is not compatible with lower bit rates than MPEG1 or encoding methods involving higher compression rates. As mobile terminals are becoming popular, the demand for such encoding methods is expected to increase in the future, and to meet the demand, the MPEG4 encoding method has been standardized. As for image encoding methods, the ISO/IEC 14496-2 standard was approved as an international standard in December 1998.

Further, a standard called H.26L (ITU-T (International Telecommunication Union Telecommunication Standardization Sector) Q6/16 VCEG (Video Coding Expert Group)), which is originally intended for encoding images for video conferences, is currently being set. Compared with the conventional encoding methods such as MPEG2 and MPEG4, H.26L requires a larger amount of calculation in encoding and decoding, but is known to achieve a higher encoding efficiency. Also, as a part of the MPEG4 activity, "Joint Model of Enhanced-Compression Video Coding" is now being established as a standard for achieving a higher encoding efficiency by incorporating functions unsupported by H.26L into the functions based on H.26L.

On the standardization schedule, the standard was approved as an international standard under the name of H.264 and MPEG-4 Part 10 (Advanced Video Coding, hereinafter referred to as AVC) in March 2003.

Meanwhile, to improve motion vector encoding using median predictions according to AVC, there has been a suggestion to adaptively use "Temporal Predictor" or "Spatio-Temporal Predictor" as predicted motion vector information in addition to "Spatial Predictor", which is defined in AVC and is determined through a median prediction (see Non-Patent Document 1, for example).

In an image information encoding device, cost function values for respective blocks are calculated by using the predicted motion vector information about the respective blocks, and optimum predicted motion vector information is selected. Through the compressed image information, flag information indicating the information as to which predicted motion vector information has been used is transmitted for each block.

Meanwhile, the macroblock size of 16×16 pixels might not be optimal for a large frame such as an UHD (Ultra High Definition: 4000×2000 pixels) frame to be encoded by a next-generation encoding method.

In view of this and for the purpose of achieving an even higher encoding efficiency than that achieved by AVC, an encoding method called HEVC (High Efficiency Video Coding) is now being standardized by JCTVC (Joint Collaboration Team—Video Coding), which is a joint standards organization of ITU-T and ISO/IEC (see Non-Patent Document 2, for example).

According to the HEVC encoding method, coding units (CUs) are defined as processing units like macroblocks of AVC. Unlike the macroblocks of AVC, the CUs are not fixed to the size of 16×16 pixels. The size of the CUs is specified in the compressed image information in each sequence.

The CUs form a hierarchical structure including the largest coding units (LCUs) and the smallest coding units (SCUs). Roughly speaking, the LCUs can be considered equivalent to the macroblocks of AVC, and the CUs on the lower hierarchical levels than the LCUs (CUs smaller than LCUs) can be considered equivalent to the sub macroblocks of AVC.

In motion vector (MV) encoding, MVs are not sent directly to a decoder, but the difference vectors (MVDs) that are the differences from predicted motion vectors (PMVs) are subjected to lossless encoding, and are then sent to the decoder. By a technique called Advanced MV prediction (AMVP) or MV competition, an index (pmv_index) for identifying PMVs is contained in each stream when there are two or more candidate PMVs (see Non-Patent Document 2, for example).

The candidate PMVs may be MVs of blocks close to each other in a frame of the same time (spatial_pmv), or MVs of blocks that differ from the encoded current frame in terms of time (temporal_pmv). Where pmv_index is encoded, the bit rate after the encoding is normally low if the value of pmv_index is small.

Therefore, to achieve a high encoding efficiency, pmv_index having a small value should be assigned to a candidate PMV having a higher designation frequency.

CITATION LIST

Non-Patent Documents

Non-Patent Document 1: Joel Jung, Guillaume Laroche, "Competition-Based Scheme for Motion Vector Selection and Coding", VCEG-AC06, ITU—Telecommunications Standardization SectorSTUDY GROUP 16 Question

6Video Coding Experts Group (VCEG)29th Meeting: Klagenfurt, Austria, 17-18 Jul., 2006

Non-Patent Document 2: “Test Model under Consideration”, JCTVC-B205, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG112nd Meeting: Geneva, CH, 21-28 Jul., 2010

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

However, the frequency at which a candidate PMV is designated depends on the contents of images. Therefore, even if code numbers are assigned in such a manner as to give priority to temporal_pmv or spatial_pmv (or if s smaller code number is assigned to temporal_pmv or spatial_pmv), there has been a possibility that the encoding efficiency becomes lower depending on the contents of images, and the lower encoding efficiency leads to a problem.

For example, if s larger code number is assigned to temporal_pmv (while a smaller code number is assigned to spatial_pmv), there is a possibility that the bit rate becomes higher when temporal_pmv is designated as a PMV, due to discontinuity or the like appearing in motion around the current block.

If a larger code number is assigned to spatial_pmv (while a smaller code number is assigned to temporal_pmv), there is a possibility that the bit rate becomes higher when spatial_pmv is designated as a PMV, due to a stop of panning of a camera, for example.

This disclosure has been made in view of the above circumstances, and the object thereof is to prevent reductions in encoding efficiency by assigning a smaller code number to temporal_pmv when the distance between the current picture and the picture containing temporal_pmv is short in terms of displaying order, and assigning a smaller code number to spatial_pmv when the distance between the current picture and the anchor picture is long in terms of displaying order, taking advantage of the fact that frames close to each other in terms of displaying order are highly likely to have similar motions.

Solutions to Problems

One aspect of this disclosure is an image processing device that includes: an assignment control unit that controls assignment of a binary bit sequence to predicted motion vector select information indicating a motion vector selected as a predicted motion vector, to assign a bit sequence having a shorter code length to the select information about a motion vector having a higher designation frequency; and a binarization unit that binarizes the predicted motion vector select information with the bit sequence assigned by the assignment control unit.

The assignment control unit may include a table selection unit that selects a table that designates the bit sequence to be assigned to the predicted motion vector select information in accordance with the type of the motion vector selected as the predicted motion vector, and the binarization unit can binarize the predicted motion vector select information by using the table selected by the table selection unit.

The assignment control unit may further include a distance calculation unit that calculates the distance between the current picture and an anchor picture, and the table selection unit can select the table based on the distance calculated by the distance calculation unit.

The assignment control unit may further include a distance threshold acquirement unit that acquires a distance threshold indicating the threshold of the distance, and the table selection unit can select the table in accordance with the magnitude relationship between the distance calculated by the distance calculation unit and the distance threshold acquired by the distance threshold acquirement unit.

The distance threshold acquired by the distance threshold acquirement unit may be supplied to another device that decodes encoded data of the predicted motion vector select information.

The assignment control unit may further include a similarity calculation unit that calculates the similarity between peripheral predicted motion vectors, and the table selection unit can select the table based on the similarity calculated by the similarity calculation unit.

The assignment control unit may further include a similarity threshold acquirement unit that acquires a similarity threshold indicating the threshold of the similarity, and the table selection unit can select the table in accordance with the magnitude relationship between the similarity calculated by the similarity calculation unit and the similarity threshold acquired by the similarity threshold acquirement unit.

The similarity threshold acquired by the similarity threshold acquirement unit may be supplied to another device that decodes encoded data of the predicted motion vector select information.

The assignment control unit may further include a cost function value calculation unit that calculates a cost function value of the predicted motion vector select information, and the table selection unit can select the table based on the cost function value calculated by the cost function value calculation unit.

Information indicating the result of the table selection performed by the table selection unit may be supplied to another device that decodes encoded data of the predicted motion vector select information.

The image processing device may further include an encoding unit that encodes the binarized data obtained through the binarization performed by the binarization unit.

The one aspect of this disclosure is also an image processing method for an image processing device. The image processing method includes: controlling assignment of a binary bit sequence to predicted motion vector select information indicating a motion vector selected as a predicted motion vector, to assign a bit sequence having a shorter code length to the select information about a motion vector having a higher designation frequency, the controlling being performed by an assignment control unit; and binarizing the predicted motion vector select information with the assigned bit sequence, the binarizing being performed by a binarization unit.

The other aspect of this disclosure is an image processing device that includes: a decoding unit that decodes encoded data of predicted motion vector select information indicating a motion vector selected as a predicted motion vector; and a debinarization unit that debinarizes the binarized data of the predicted motion vector select information obtained through the decoding performed by the decoding unit, with a bit sequence that is assigned in an assigning operation controlled to assign a bit sequence having a shorter code length to the select information about a motion vector having a higher designation frequency.

The image processing device may further including an assignment control unit that controls the bit sequence to be assigned to the predicted motion vector select information based on a parameter supplied from another device that has encoded the predicted motion vector select information. The debinarization unit can debinarize the predicted motion vector select information under the control of the assignment control unit.

The assignment control unit may include a table selection unit that selects a table that designates the bit sequence to be assigned to the predicted motion vector select information in accordance with the type of the motion vector selected as the predicted motion vector.

The assignment control unit may further include a distance calculation unit that calculates the distance between the current picture and an anchor picture, and the table selection unit can select the table in accordance with the magnitude relationship between the distance calculated by the distance calculation unit and a distance threshold supplied from the other device that has encoded the predicted motion vector select information.

The assignment control unit may further include a similarity calculation unit that calculates the similarity between peripheral predicted motion vectors, and the table selection unit can select the table in accordance with the magnitude relationship between the similarity calculated by the similarity calculation unit and a similarity threshold supplied from the other device that has encoded the predicted motion vector select information.

The debinarization unit may debinarize the binarized data of the predicted motion vector select information based on information indicating a table selection result supplied from the other device that has encoded the predicted motion vector select information.

The other aspect of this disclosure is also an image processing method for an image processing device. The image processing method includes: decoding encoded data of predicted motion vector select information indicating a motion vector selected as a predicted motion vector, the decoding being performed by a decoding unit; and debinarizing the binarized data of the predicted motion vector select information obtained through the decoding, with a bit sequence that is assigned in an assigning operation controlled to assign a bit sequence having a shorter code length to the select information about a motion vector having a higher designation frequency, the debinarizing being performed by a debinarization unit.

In the one aspect of this disclosure, assignment of a binary bit sequence to predicted motion vector select information indicating a motion vector selected as a predicted motion vector is controlled so as to assign a bit sequence having a shorter code length to the select information about a motion vector having a higher designation frequency, and the predicted motion vector select information is binarized with the assigned bit sequence.

In the other aspect of this disclosure, encoded data of predicted motion vector select information indicating a motion vector selected as a predicted motion vector is decoded, and the binarized data of the predicted motion vector select information obtained through the decoding is debinarized with a bit sequence that is assigned in an assigning operation controlled so as to assign a bit sequence having a shorter code length to the select information about a motion vector having a higher designation frequency.

Effects of the Invention

According to this disclosure, images can be processed. Particularly, encoding efficiency can be increased.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a block diagram showing an image encoding device that outputs compressed image information according to the AVC encoding method.

FIG. **2** is a block diagram showing an image decoding device that receives an input of compressed image information according to the AVC encoding method.

FIG. **3** is a diagram showing an example motion prediction/compensation operation with decimal pixel precision.

FIG. **4** is a diagram showing example macroblocks.

FIG. **5** is a diagram for explaining an example situation of a median operation.

FIG. **6** is a diagram for explaining an example Multi-Reference Frame.

FIG. **7** is a diagram for explaining an example situation in Temporal Direct Mode.

FIG. **8** is a diagram for explaining an example situation according to a motion vector encoding method suggested in Non-Patent Document 1.

FIG. **9** is a diagram for explaining example structures of coding units.

FIG. **10** is a block diagram showing a typical example structure of an image encoding device.

FIG. **11** is a diagram for explaining example candidate PMVs for AMVP.

FIG. **12** is a diagram for explaining the relationship between MV_Tmp and the difference between the current picture and the anchor picture in terms of displaying order.

FIG. **13** is a diagram for explaining the relationship between MV_Tmp and the difference between the current picture and the anchor picture in terms of displaying order.

FIG. **14** is a block diagram showing typical example structures of the lossless encoding unit and the assignment control unit shown in FIG. **11**.

FIG. **15** is a diagram for explaining an example pattern of assignment of code numbers and bit sequences.

FIG. **16** is a flowchart for explaining an example flow of an encoding operation.

FIG. **17** is a flowchart for explaining an example flow of a lossless encoding operation.

FIG. **18** is a flowchart for explaining an example flow of an inter prediction mode information encoding operation.

FIG. **19** is a block diagram showing a typical example structure of an image decoding device.

FIG. **20** is a block diagram showing typical example structures of the lossless decoding unit and the assignment control unit shown in FIG. **19**.

FIG. **21** is a flowchart for explaining an example flow of a decoding operation.

FIG. **22** is a flowchart for explaining an example flow of a lossless decoding operation.

FIG. **23** is a flowchart for explaining an example flow of an inter prediction mode information decoding operation.

FIG. **24** is a diagram for explaining another example pattern of assignment of code numbers and bit sequences.

FIG. **25** is a diagram for explaining yet another example pattern of assignment of code numbers and bit sequences.

FIG. **26** is a block diagram showing typical example structures of the lossless encoding unit and the assignment control unit shown in FIG. **11**.

FIG. **27** is a diagram for explaining an example relationship between peripheral motion vectors.

FIG. **28** is a diagram for explaining another example relationship between peripheral motion vectors.

FIG. **29** is a diagram for explaining yet another example relationship between peripheral motion vectors.

FIG. **30** is a diagram for explaining still another example relationship between peripheral motion vectors.

FIG. **31** is a diagram for explaining yet another example relationship between peripheral motion vectors.

FIG. **32** is a flowchart for explaining another example flow of the inter prediction mode information encoding operation.

FIG. **33** is a block diagram showing typical example structures of the lossless decoding unit and the assignment control unit shown in FIG. **19**.

FIG. **34** is a flowchart for explaining another example flow of the inter prediction mode information decoding operation.

FIG. **35** is a block diagram showing other typical example structures of the lossless encoding unit and the assignment control unit shown in FIG. **11**.

FIG. **36** is a flowchart for explaining yet another example flow of the inter prediction mode information encoding operation.

FIG. **37** is a block diagram showing other typical example structures of the lossless decoding unit and the assignment control unit shown in FIG. **19**.

FIG. **38** is a flowchart for explaining yet another example flow of the inter prediction mode information decoding operation.

FIG. **39** is a block diagram showing a typical example structure of a personal computer.

FIG. **40** is a block diagram showing a typical example structure of a television receiver.

FIG. **41** is a block diagram showing a typical example structure of a portable telephone device.

FIG. **42** is a block diagram showing a typical example structure of a hard disk recorder.

FIG. **43** is a block diagram showing a typical example structure of a camera.

MODES FOR CARRYING OUT THE INVENTION

The following is a description of modes for carrying out the present technique (hereinafter referred to as the embodiments). Explanation will be made in the following order.

1. First Embodiment (Image Encoding Device and Image Decoding Device)
2. Second Embodiment (Image Encoding Device and Image Decoding Device)
3. Third Embodiment (Image Encoding Device and Image Decoding Device)
4. Fourth Embodiment (Personal Computer)
5. Fifth Embodiment (Television Receiver)
6. Sixth Embodiment (Portable Telephone Device)
7. Seventh Embodiment (Hard Disk Recorder)
8. Eighth Embodiment (Camera)

<1. First Embodiment>

[Image Encoding Device Compatible with the AVC Encoding Method]

FIG. **1** shows the structure of an embodiment of an image encoding device that encodes images by the H.264 and MPEG (Moving Picture Experts Group) 4 Part 10 (AVC (Advanced Video Coding)) encoding methods.

The image encoding device **100** shown in FIG. **1** is a device that encodes and outputs images by an encoding method compliant with the AVC standard. As shown in FIG. **1**, the image encoding device **100** includes an A/D converter **101**, a screen rearrangement buffer **102**, an arithmetic operation unit **103**, an orthogonal transform unit **104**, a quantization unit **105**, a lossless encoding unit **106**, and an accumulation buffer **107**. The image encoding device **100** also includes an inverse quantization unit **108**, an inverse orthogonal transform unit **109**, an arithmetic operation unit **110**, a deblocking filter **111**, a frame memory **112**, a selection unit **113**, an intra prediction unit **114**, a motion prediction/compensation unit **115**, a selection unit **116**, and a rate control unit **117**.

The A/D converter **101** subjects input image data to an A/D conversion, and outputs and stores the resultant image data into the screen rearrangement buffer **102**. The screen rearrangement buffer **102** rearranges the image frames stored in displaying order in accordance with the GOP (Group of Pictures) structure, so that the frames are arranged in encoding order.

The screen rearrangement buffer **102** supplies the image having the rearranged frame order to the arithmetic operation unit **103**. The screen rearrangement buffer **102** also supplies the image having the rearranged frame order to the intra prediction unit **114** and the motion prediction/compensation unit **115**.

The arithmetic operation unit **103** subtracts a predicted image supplied from the intra prediction unit **114** or the motion prediction/compensation unit **115** via the selection unit **116**, from the image read from the screen rearrangement buffer **102**, and outputs the difference information to the orthogonal transform unit **104**.

When intra encoding is performed on an image, for example, the arithmetic operation unit **103** subtracts a predicted image supplied from the intra prediction unit **114**, from the image read from the screen rearrangement buffer **102**. When inter encoding is performed on an image, for example, the arithmetic operation unit **103** subtracts a predicted image supplied from the motion prediction/compensation unit **115**, from the image read from the screen rearrangement buffer **102**.

The orthogonal transform unit **104** performs an orthogonal transform operation, such as a discrete cosine transform or a Karhunen-Loeve transform, on the difference information supplied from the arithmetic operation unit **103**, and supplies the transform coefficient to the quantization unit **105**.

The quantization unit **105** quantizes the transform coefficient output from the orthogonal transform unit **104**. Based on target bit rate value information supplied from the rate control unit **117**, the quantization unit **105** sets a quantization parameter, and performs quantization. The quantization unit **105** supplies the quantized transform coefficient to the lossless encoding unit **106**.

The lossless encoding unit **106** performs lossless encoding on the quantized transform coefficient through variable-length encoding or arithmetic encoding or the like. Since the coefficient data has already been quantized under the control of the rate control unit **117**, the bit rate becomes equal to the target value (or approximates the target value) that is set by the rate control unit **117**.

The lossless encoding unit **106** obtains information indicating an intra prediction and the like from the intra prediction unit **114**, and obtains information indicating an inter prediction mode, motion vector information, and the like from the motion prediction/compensation unit **115**. The information indicating an intra prediction (an intra-screen prediction) will be hereinafter also referred to as intra prediction mode information. The information indicating an inter prediction (an inter-screen prediction) will be hereinafter referred to as inter prediction mode information.

The lossless encoding unit **106** not only encodes the quantized transform coefficient, but also incorporates (multiplexes) various kinds of information such as a filter coefficient, the intra prediction mode information, the inter prediction mode information, and the quantization parameter, into the header information of encoded data. The lossless encoding unit **106** supplies and stores the encoded data obtained through the encoding into the accumulation buffer **107**.

For example, in the lossless encoding unit **106**, a lossless encoding operation such as variable-length encoding or arithmetic encoding is performed. The variable-length encoding may be CAVLC (Context-Adaptive Variable Length Coding) specified in H.264/AVC, for example. The arithmetic encoding may be CABAC (Context-Adaptive Binary Arithmetic Coding) or the like.

The accumulation buffer **107** temporarily stores the encoded data supplied from the lossless encoding unit **106**, and outputs the encoded data as an encoded image encoded by H.264/AVC to a recording device or a transmission path (not shown) in a later stage at a predetermined time, for example.

The transform coefficient quantized at the quantization unit **105** is also supplied to the inverse quantization unit **108**. The inverse quantization unit **108** inversely quantizes the quantized transform coefficient by a method compatible with the quantization performed by the quantization unit **105**. The inverse quantization unit **108** supplies the obtained transform coefficient to the inverse orthogonal transform unit **109**.

The inverse orthogonal transform unit **109** performs an inverse orthogonal transform on the supplied transform coefficient by a method compatible with the orthogonal transform operation performed by the orthogonal transform unit **104**. The output subjected to the inverse orthogonal transform (the restored difference information) is supplied to the arithmetic operation unit **110**.

The arithmetic operation unit **110** obtains a locally decoded image (a decoded image) by adding the predicted image supplied from the intra prediction unit **114** or the motion prediction/compensation unit **115** via the selection unit **116** to the inverse orthogonal transform result supplied from the inverse orthogonal transform unit **109** or the restored difference information.

For example, when the difference information is compatible with an image to be intra-encoded, the arithmetic operation unit **110** adds the predicted image supplied from the intra prediction unit **114** to the difference information. When the difference information is compatible with an image to be inter-encoded, the arithmetic operation unit **110** adds the predicted image supplied from the motion prediction/compensation unit **115** to the difference information, for example.

The addition result is supplied to the deblocking filter **111** or the frame memory **112**.

The deblocking filter **111** removes block distortions from the decoded image by performing a deblocking filtering operation where necessary. The deblocking filter **111** supplies the filtering operation result to the frame memory **112**. The decoded image that is output from the arithmetic operation unit **110** can be supplied to the frame memory **112** without passing through the deblocking filter **111**. That is, the deblocking filtering operation of the deblocking filter **111** can be skipped.

The frame memory **112** stores the supplied decoded image, and outputs the stored decoded image as a reference image to the intra prediction unit **114** or the motion prediction/compensation unit **115** via the selection unit **113** at a predetermined time.

When intra encoding is performed on an image, for example, the frame memory **112** supplies the reference image to the intra prediction unit **114** via the selection unit **113**. When inter encoding is performed on an image, for example, the frame memory **112** supplies the reference image to the motion prediction/compensation unit **115** via the selection unit **113**.

When the reference image supplied from the frame memory **112** is an image to be subjected to intra encoding, the selection unit **113** supplies the reference image to the intra prediction unit **114**. When the reference image supplied from the frame memory **112** is an image to be subjected to inter encoding, the selection unit **113** supplies the reference image to the motion prediction/compensation unit **115**.

The intra prediction unit **114** performs intra predictions (intra-screen predictions) to generate a predicted image by using the pixel values in the current picture supplied from the frame memory **112** via the selection unit **113**. The intra prediction unit **114** performs intra predictions in more than one mode (intra prediction modes) that is prepared in advance.

By the H.264 image information encoding method, an intra 4×4 prediction mode, an intra 8×8 prediction mode, and an intra 16×16 prediction mode are defined for luminance signals. As for chrominance signals, prediction modes for respective macroblocks can be defined independently of the luminance signals. In the intra 4×4 prediction mode, one intra prediction mode is defined for each 4×4 luminance block. In the intra 8×8 prediction mode, one intra prediction mode is defined for each 8×8 luminance block. In the intra 16×16 prediction mode and for the chrominance signals, one prediction mode is defined for each macroblock.

The intra prediction unit **114** generates predicted images in all the candidate intra prediction modes, evaluates the cost function values of the respective predicted images by using the input image supplied from the screen rearrangement buffer **102**, and selects an optimum mode. After selecting the optimum intra prediction mode, the intra prediction unit **114** supplies the predicted image generated in the optimum intra prediction mode to the arithmetic operation unit **103** and the arithmetic operation unit **110** via the selection unit **116**.

As described above, the intra prediction unit **114** also supplies information such as the intra prediction mode information indicating the adopted intra prediction mode to the lossless encoding unit **106** where appropriate.

Using the input image supplied from the screen rearrangement buffer **102**, and the reference image supplied from the frame memory **112** via the selection unit **113**, the motion prediction/compensation unit **115** performs motion predictions (inter predictions) on an image to be subjected to inter encoding, and performs a motion compensation operation in accordance with the detected motion vectors, to generate a predicted image (inter predicted image information). The motion prediction/compensation unit **115** performs such inter predictions in more than one mode (inter prediction modes) that is prepared in advance.

The motion prediction/compensation unit **115** generates predicted images in all the candidate inter prediction modes, evaluates the cost function values of the respective predicted images, and selects an optimum mode. The motion prediction/compensation unit **115** supplies the generated predicted image to the arithmetic operation unit **103** and the arithmetic operation unit **110** via the selection unit **116**.

The motion prediction/compensation unit **115** supplies the inter prediction mode information indicating the adopted inter prediction mode, and motion vector information indicating the calculated motion vectors to the lossless encoding unit **106**.

When intra encoding is performed on an image, the selection unit **116** supplies the output of the intra prediction unit **114** to the arithmetic operation unit **103** and the arithmetic operation unit **110**. When inter encoding is performed on an image, the selection unit **116** supplies the output of the motion prediction/compensation unit **115** to the arithmetic operation unit **103** and the arithmetic operation unit **110**.

Based on the compressed images accumulated in the accumulation buffer **107**, the rate control unit **117** controls the quantization operation rate of the quantization unit **105** so as not to cause an overflow or underflow.

[Image Decoding Device Compatible with the AVC Encoding Method]

FIG. **2** is a block diagram showing a typical example structure of an image decoding device that realizes image compression through orthogonal transforms, such as discrete cosine transforms or Karhunen-Loeve transforms, and motion compensation. The image decoding device **200** shown in FIG. **2** is a decoding device that is compatible with the image encoding device **100** shown in FIG. **1**.

Data encoded by the image encoding device **100** is supplied to the image decoding device **200** compatible with the image encoding device **100** via a passage such as a transmission path or a recording medium, and is then decoded.

As shown in FIG. **2**, the image decoding device **200** includes an accumulation buffer **201**, a lossless decoding unit **202**, an inverse quantization unit **203**, an inverse orthogonal transform unit **204**, an arithmetic operation unit **205**, a deblocking filter **206**, a screen rearrangement buffer **207**, and a D/A converter **208**. The image decoding device **200** also includes a frame memory **209**, a selection unit **210**, an intra prediction unit **211**, a motion prediction/compensation unit **212**, and a selection unit **213**.

The accumulation buffer **201** accumulates transmitted encoded data. The encoded data has been encoded by the image encoding device **100**. The lossless decoding unit **202** decodes the encoded data read from the accumulation buffer **201** at a predetermined time, by a method compatible with the encoding method used by the lossless encoding unit **106** shown in FIG. **1**.

When the current frame is an intra-encoded frame, the header portion of the encoded data stores intra prediction mode information. The lossless decoding unit **202** also decodes the intra prediction mode information, and supplies the resultant information to the intra prediction unit **211**. When the current frame is an inter-encoded frame, on the other hand, the header portion of the encoded data stores motion vector information. The lossless decoding unit **202** also decodes the motion vector information, and supplies the resultant information to the motion prediction/compensation unit **212**.

The inverse quantization unit **203** inversely quantizes the coefficient data (the quantized coefficient) decoded by the lossless decoding unit **202**, by a method compatible with the quantization method used by the quantization unit **105** shown in FIG. **1**. That is, the inverse quantization unit **203** inversely quantizes the quantized coefficient by the same method as the method used by the inverse quantization unit **108** shown in FIG. **1**.

The inverse quantization unit **203** supplies the inversely-quantized coefficient data, or the orthogonal transform coefficient, to the inverse orthogonal transform unit **204**. The inverse orthogonal transform unit **204** subjects the orthogonal transform coefficient to an inverse orthogonal transform by a method compatible with the orthogonal transform method used by the orthogonal transform unit **104** shown in FIG. **1** (the same method as the method used by the inverse orthogonal transform unit **109** shown in FIG. **1**), and obtains decoded residual error data corresponding to the residual error data from the time prior to the orthogonal transform performed by the image encoding device **100**. For example, a fourth-order inverse orthogonal transform is performed.

The decoded residual error data obtained through the inverse orthogonal transform is supplied to the arithmetic operation unit **205**. A predicted image is also supplied to the arithmetic operation unit **205** from the intra prediction unit **211** or the motion prediction/compensation unit **212** via the selection unit **213**.

The arithmetic operation unit **205** adds the decoded residual error data to the predicted image, and obtains decoded image data corresponding to the image data from the time prior to the predicted image subtraction performed by the arithmetic operation unit **103** of the image encoding device **100**. The arithmetic operation unit **205** supplies the decoded image data to the deblocking filter **206**.

The deblocking filter **206** removes block distortions from the supplied decoded images, and supplies the images to the screen rearrangement buffer **207**.

The screen rearrangement buffer **207** performs image rearrangement. Specifically, the frame sequence rearranged in the encoding order by the screen rearrangement buffer **102** shown in FIG. **1** is rearranged in the original displaying order. The D/A converter **208** performs a D/A conversion on the images supplied from the screen rearrangement buffer **207**, and outputs the converted images to a display (not shown) to display the images.

The output of the deblocking filter **206** is further supplied to the frame memory **209**.

The frame memory **209**, the selection unit **210**, the intra prediction unit **211**, the motion prediction/compensation unit **212**, and the selection unit **213** are equivalent to the frame memory **112**, the selection unit **113**, the intra prediction unit **114**, the motion prediction/compensation unit **115**, and the selection unit **116** of the image encoding device **100**, respectively.

The selection unit **210** reads, from the frame memory **209**, an image to be inter-processed and an image to be referred to, and supplies the images to the motion prediction/compensation unit **212**. The selection unit **210** also reads an image to be used for intra predictions from the frame memory **209**, and supplies the image to the intra prediction unit **211**.

Information that has been obtained by decoding the header information and indicates an intra prediction mode or the like is supplied, where appropriate, from the lossless decoding unit **202** to the intra prediction unit **211**. Based on the information, the intra prediction unit **211** generates a predicted image from the reference image obtained from the frame memory **209**, and supplies the generated predicted image to the selection unit **213**.

The motion prediction/compensation unit **212** obtains the information obtained by decoding the header information (prediction mode information, motion vector information, reference frame information, a flag, respective parameters, and the like), from the lossless decoding unit **202**.

Based on the information supplied from the lossless decoding unit **202**, the motion prediction/compensation unit **212** generates a predicted image from the reference image obtained from the frame memory **209**, and supplies the generated predicted image to the selection unit **213**.

The selection unit **213** selects a predicted image generated by the motion prediction/compensation unit **212** or the intra prediction unit **211**, and supplies the selected predicted image to the arithmetic operation unit **205**.

[Motion Prediction/Compensation Operation with Decimal Pixel Precision]

By an encoding method such as MPEG2, motion prediction/compensation operations with ½ pixel precision are performed through linear interpolations. By the AVC encoding method, on the other hand, motion prediction/compensation operations with ¼ pixel precision using a 6-tap FIR filter are performed, and encoding efficiency is increased accordingly.

FIG. **3** is a diagram for explaining an example motion prediction/compensation operation with ¼ pixel precision specified by the AVC encoding method. In FIG. **3**, each square represents a pixel. Among those squares, each A represents the position of an integer precision pixel stored in the frame memory **112**, b, c, and d represent the positions of ½ precision pixels, and e_1, e_2, and e_3 represent the positions of ¼ precision pixels.

In the following, the function Clip 1( ) is defined as shown in the following equation (1):

[Mathematical Formula 1]

$$\mathrm{Clip1}(a) = \begin{cases} 0; & \text{if } (a < 0) \\ a; & \text{otherwise} \\ \mathrm{max\_pix}; & \text{if } (a > \mathrm{max\_pix}) \end{cases} \tag{1}$$

When an input image has 8-bit precision, for example, the value of max_pix in the equation (1) is 255.

The pixel values in the positions represented by b and d are generated by using a 6-tap FIR filter, as shown in the following equations (2) and (3):

[Mathematical Formula 2]

$$F=A_{-2}-5\cdot A_{-1}+20\cdot A_0+20\cdot A_1-5\cdot A_2+A_3 \tag{2}$$

[Mathematical Formula 3]

$$b,d=\mathrm{Clip\ 1}((F+16)>>5) \tag{3}$$

The pixel value in the position represented by c is generated by using a 6-tap FIR filter in the horizontal direction and the vertical direction, as shown in the following equations (4) through (6):

[Mathematical Formula 4]

$$F=b_{-2}-5\cdot b_{-1}+20\cdot b_0+20\cdot b_1-5\cdot b_2+b_3 \tag{4}$$

or

[Mathematical Formula 5]

$$F=d_{-2}-5\cdot d_{-1}+20\cdot d_0+20\cdot d_1-5\cdot d_2+d_3 \tag{5}$$

[Mathematical Formula 6]

$$c=\mathrm{Clip1}((F+512)>>10) \tag{6}$$

The Clip operation is only once performed at last, after both the horizontal product-sum operation and the vertical product-sum operation are performed.

Meanwhile, e_1 through e_3 are generated through linear interpolations, as shown in the following equations (7) through (9):

[Mathematical Formula 7]

$$e_1=(A+b+1)>>1 \tag{7}$$

[Mathematical Formula 8]

$$e_2=(b+d+1)>>1 \tag{8}$$

[Mathematical Formula 9]

$$e_3=(b+c+1)>>1 \tag{9}$$

[Motion Prediction/Compensation Operation]

In MPEG2, each unit in motion prediction/compensation operations is 16×16 pixels in a frame motion compensation mode, and is 16×8 pixels in each of a first field and a second field in a field motion compensation mode. With such units, motion prediction/compensation operations are performed.

In AVC, on the other hand, each one macroblock formed with 16×16 pixels is divided into 16×16, 16×8, 8×16, or 8×8 parts, as shown in FIG. **4**, and those parts can have motion vector information independently of one another on a sub macroblock basis. Each 8×8 part can be further divided into 8×8, 8×4, 4×8, or 4×4 sub macroblocks that can have motion vector information independently of one another, as shown in FIG. **4**.

By the AVC image encoding method, however, there is a possibility that an enormous amount of motion vector information is generated if such motion prediction/compensation operations are performed, as in the case of MPEG2. Encoding the generated motion vector information without any change might lead to a decrease in encoding efficiency.

[Motion Vector Median Prediction]

To solve this problem, the method described below is used in AVC image encoding, and a decrease in the amount of encoded motion vector information is realized.

Each straight line shown in FIG. **5** indicates a boundary between motion compensation blocks. In FIG. **5**, E represents the current motion compensation block to be encoded, and A through D each represents a motion compensation block that has already been encoded and is adjacent to E.

Where X is A, B, C, D, or E, mv_x represents the motion vector information about a block X.

By using the motion vector information about the motion compensation blocks A, B, and C, predicted motion vector information pmv_E about the motion compensation block E is generated through a median operation as shown in the following equation (10):

[Mathematical Formula 10]

$$pmv_E=\mathrm{med}(mv_A,mv_B,mv_C) \tag{10}$$

If the information about the motion compensation block C is “unavailable” because the block C is located at a corner of the image frame or the like, the information about the motion compensation block D is used instead.

In the compressed image information, the data mvd_E to be encoded as the motion vector information about the motion compensation block E is generated by using pmv_E as shown in the following equation (11).

[Mathematical Formula 11]

$$mvd_E=mv_E-pmv_E \tag{11}$$

In an actual operation, processing is performed on the horizontal component and the vertical component of the motion vector information independently of each other.

[Multi-Reference Frame]

In AVC, Multi-Reference Frame method, which is not specified by conventional image encoding methods such as MPEG2 or H.263, is specified.

Referring now to FIG. **6**, Multi-Reference Frame specified in AVC is described.

In MPEG-2 and H.263, a motion prediction/compensation operation is performed by referring to only one reference frame stored in a frame memory in the case of a P-picture. In AVC, however, more than one reference frame is stored in a memory, and a different memory can be referred to for each macroblock, as shown in FIG. **5**.

[Direct Modes]

Although the amount of motion vector information in a B-picture is very large, there are predetermined modes called Direct Modes in AVC.

In Direct Modes, motion vector information is not stored in compressed image information. In an image decoding device, the motion vector information about a current block to be processed is calculated from the motion vector information about a peripheral block or the motion vector information about a co-located block that is a block located in the same position as the current block in a reference frame.

Direct Modes includes the two modes: Spatial Direct Mode and Temporal Direct Mode. One of the two modes can be selected for each slice.

In Spatial Direct Mode, the motion vector information mv_E about the motion compensation block E to be processed is calculated as shown in the following equation (12):

$$mv_E = pmv_E \quad (12)$$

That is, motion vector information that is generated through a median prediction is applied to the current block.

Referring now to FIG. 7, Temporal Direct Mode is described.

In FIG. 7, the block located at the address of the same space as the current block in a L0 reference picture is referred to as a co-located block, and the motion vector information about the co-located block is represented by mv_{col}. Also, TD_E, represents the distance on the temporal axis between the current picture and the L0 reference picture, and TD_D represents the distance on the temporal axis between the L0 reference picture and an L1 reference picture.

At this point, the motion vector information mv_{L0} about L0 and the motion vector information mv_{L1} about L1 in the current picture are calculated as shown in the following equations (13) and (14):

[Mathematical Formula 12]

$$mv_{L0} = \frac{TD_B}{TD_D} mv_{col} \quad (13)$$

[Mathematical Formula 13]

$$mv_{L1} = \frac{TD_D - TD_B}{TD_D} mv_{col} \quad (14)$$

In AVC compressed image information, information indicating a distance on the temporal axis TD does not exist, and therefore, the calculations according to the above mentioned equations (12) and (13) are performed by using POC (Picture Order Count).

In AVC compressed image information, Direct Modes can be defined on a 16×16 pixel macroblock basis or an 8×8 pixel block basis.

[Prediction Mode Selection]

To achieve higher encoding efficiency, it is critical to select an appropriate prediction mode by the AVC encoding method.

An example of such a selection method is a method stored in the H.264/MPEG-4 AVC reference software, called JM (Joint Model) (available from http://iphome.hhi.de/suehring/tml/index.htm).

In JM, a method of determining a mode between two modes, which are High Complexity Mode and Low Complexity Mode, can be selected as described below. In either of the modes, the cost function value as to each prediction mode is calculated, and the prediction mode that minimizes the cost function value is selected as the optimum mode for the current sub macroblock or the current macroblock.

A cost function in High Complexity Mode can be calculated as shown in the following equation (15):

$$\mathrm{Cost}(\mathrm{Mode} \in \Omega) = D + \lambda * R \quad (15)$$

Here, Ω represents the universal set of candidate modes for encoding the current block or macroblock, and D represents the difference energy between a decoded image and an input image when encoding is performed in the prediction mode. λ represents the Lagrange's undetermined multiplier provided as the quantization parameter function. R represents the total bit rate in a case where encoding is performed in the mode, including the orthogonal transform coefficient.

That is, to perform encoding in High Complexity Mode, a provisional encoding operation needs to be performed in all the candidate modes to calculate the above parameters D and R, and therefore, a larger amount of calculation is required.

A cost function in Low Complexity Mode can be calculated as shown in the following equation (16):

$$\mathrm{Cost}(\mathrm{Mode} \in \Omega) = D + QP2\mathrm{Quant}(\mathrm{QP}) * \mathrm{HeaderBit} \quad (16)$$

Here, D differs from that in High Complexity Mode, and represents the difference energy between a predicted image and an input image. QP2Quant(QP) is a function of a quantization parameter QP, and HeaderBit represents the bit rate related to information that excludes the orthogonal transform coefficient and belongs to Header, such as motion vectors and the mode.

That is, in Low Complexity Mode, a predicting operation needs to be performed for each of the candidate modes, but a decoded image is not required. Therefore, there is no need to perform an encoding operation. Accordingly, the calculation amount can be smaller than that in High Complexity Mode.

[Competition Among Motion Vectors]

To improve motion vector encoding using median predictions as described above with reference to FIG. 5, Non-Patent Document 1 suggests the method described below.

That is, in addition to "Spatial Predictor" determined through a median prediction and defined in AVC, one of "Temporal Predictor" and "Spatio-Temporal Predictor" described below can be adaptively used as predicted motion vector information.

Specifically, in FIG. 8, "mvcol" represents the motion vector information about a co-located block (a block having the same x-y coordinates as the current block in a reference image) of the current block, and "mvtk" (k being one of 0 through 8) represents the motion vector information about a peripheral block. The predicted motion vector information (Predictor) about each block is defined as shown in the following equations (17) through (19):

Temporal Predictor:

[Mathematical Formula 14]

$$mv_{tm5} = \mathrm{median}\{mv_{col}, mv_{t0}, \ldots, mv_{t3}\} \quad (17)$$

[Mathematical Formula 15]

$$mv_{tm9} = \mathrm{median}\{mv_{col}, mv_{t0}, \ldots, mv_{t8}\} \quad (18)$$

Spatio-Temporal Predictor:

[Mathematical Formula 16]

$$mv_{spt} = \mathrm{median}\{mv_{col}, mv_{col}, mv_a, mv_b, mv_c\} \quad (19)$$

In the image encoding device 100, the cost function values for respective blocks are calculated by using the predicted motion vector information about the respective blocks, and optimum predicted motion vector information is selected. Through the compressed image information, a flag indicating the information as to which predicted motion vector information has been used is transmitted for each block.

[Coding Unit]

The macroblock size of 16×16 pixels is not optimal for large frames such as UHD (Ultra High Definition: 4000×2000 pixels) frames to be encoded by a next-generation encoding method.

In view of this, AVC specifies a hierarchical structure formed with macroblocks and sub macroblocks as shown in FIG. 4. In HEVC (High Efficiency Video Coding), however, coding units (CUs) are specified as shown in FIG. 9.

CUs are also called Coding Tree Blocks (CTBs), and are partial regions of picture-based images that have the same roles as those of macroblocks in AVC. While the size of the latter is limited to the size of 16×16 pixels, the size of the former is not limited to a certain size, and may be designated by the compressed image information in each sequence.

For example, in a sequence parameter set (SPS) contained in encoded data to be output, the largest coding unit (LCU) and the smallest coding unit (SCU) of the CUs are specified.

In each LCU, split-flag=1 is set within a range not lower than the SCU size, so that each LCU can be divided into CUs of a smaller size. In the example shown in FIG. **9**, the size of the LCU is 128, and the greatest hierarchical depth is 5. When the value of split_flag is "1", a CU of 2N×2N in size is divided into CUs of N×N in size, which is one hierarchical level lower.

Each of the CUs is further divided into prediction units (PUs) that are processing-unit regions (partial regions of picture-based images) for intra or inter predictions, or are divided into transform units (TUs) that are processing-unit regions (partial regions of picture-based images) for orthogonal transforms. At present, 16×16 and 32×32 orthogonal transforms, as well as 4×4 and 8×8 orthogonal transforms, can be used in HEVC.

In a case where CUs are defined, and each processing operation is performed on the CU basis in an encoding operation as in the above described HEVC, the macroblocks in AVC can be considered equivalent to the LCUs. However, a CU has a hierarchical structure as shown in FIG. **9**. Therefore, the size of the LCU on the highest hierarchical level is normally as large as 128×128 pixels, which is larger than the size of each macroblock in AVC, for example.

[Remarks on this Embodiment]

As described above, various predicted motion vectors are prepared. However, when predicted motion vector select information (pmv_index) indicating which predicted motion vector is to be adopted is encoded, a shorter code sequence to be assigned as binarized data is desirable, as the bit rate can be reduced with a shorter code sequence. That is, it is preferable to assign a shorter bit sequence to a predicted motion vector having a higher designation frequency.

However, the frequency varies depending on the contents of images and the like. Therefore, there might be a case where temporal_pmv is more frequently designated in an image, while spatial_pmv is more frequently designated in another image. In view of this, there is a possibility that bit sequences are not appropriately assigned to the respective predicted motion vectors with respect to the designation frequencies of the respective predicted motion vectors, and the encoding efficiency becomes lower.

Therefore, in the following description, a smaller code number is assigned to temporal_pmv when the current picture and the anchor picture containing temporal_pmv are close to each other in terms of displaying order, by taking advantage of the fact that there is a high possibility that motions of frames close to each other in terms of displaying order are similar. When the current picture and the anchor picture are large, a smaller code number is assigned to spatial_pmv. The following is a description of this method.

[Image Encoding Device]

FIG. **10** is a block diagram showing a typical example structure of an image encoding device.

The image encoding device **300** shown in FIG. **10** is basically the same device as the image encoding device **100** shown in FIG. **1**, and encodes image data. As shown in FIG. **11**, the image encoding device **300** includes an A/D converter **301**, a screen rearrangement buffer **302**, an arithmetic operation unit **303**, an orthogonal transform unit **304**, a quantization unit **305**, a lossless encoding unit **306**, and an accumulation buffer **307**. The image encoding device **300** also includes an inverse quantization unit **308**, an inverse orthogonal transform unit **309**, an arithmetic operation unit **310**, a loop filter **311**, a frame memory **312**, a selection unit **313**, an intra prediction unit **314**, a motion prediction/compensation unit **315**, a selection unit **316**, and a rate control unit **317**.

The image encoding device **300** further includes an assignment control unit **321**.

The A/D converter **301** performs an A/D conversion on input image data. The A/D converter **301** supplies and stores the converted image data (digital data) into the screen rearrangement buffer **302**. The screen rearrangement buffer **302** rearranges the image frames stored in displaying order in accordance with the GOP, so that the frames are arranged in encoding order. The screen rearrangement buffer **302** supplies the image having the rearranged frame order to the arithmetic operation unit **303**. The screen rearrangement buffer **302** also supplies the image having the rearranged frame order to the intra prediction unit **314** and the motion prediction/compensation unit **315**.

The arithmetic operation unit **303** subtracts a predicted image supplied from the intra prediction unit **314** or the motion prediction/compensation unit **315** via the selection unit **316**, from the image read from the screen rearrangement buffer **302**. The arithmetic operation unit **303** then outputs the difference information to the orthogonal transform unit **304**.

When intra encoding is performed on an image, for example, the arithmetic operation unit **303** subtracts a predicted image supplied from the intra prediction unit **314**, from the image read from the screen rearrangement buffer **302**. When inter encoding is performed on an image, for example, the arithmetic operation unit **303** subtracts a predicted image supplied from the motion prediction/compensation unit **315**, from the image read from the screen rearrangement buffer **302**.

The orthogonal transform unit **304** performs an orthogonal transform operation, such as a discrete cosine transform or a Karhunen-Loeve transform, on the difference information supplied from the arithmetic operation unit **303**. This orthogonal transform is performed by any appropriate method. The orthogonal transform unit **304** supplies the transform coefficient to the quantization unit **305**.

The quantization unit **305** quantizes the transform coefficient supplied from the orthogonal transform unit **304**. Based on target bit rate value information supplied from the rate control unit **317**, the quantization unit **305** sets a quantization parameter, and performs quantization. This quantization is performed by any appropriate method. The quantization unit **305** supplies the quantized transform coefficient to the lossless encoding unit **306**.

The lossless encoding unit **306** encodes the transform coefficient quantized at the quantization unit **305** by an appropriate encoding method. Since the coefficient data has already been quantized under the control of the rate control unit **317**, the bit rate becomes equal to the target value (or approximates the target value) that is set by the rate control unit **317**.

The lossless encoding unit **306** obtains information indicating an intra prediction mode and the like from the intra prediction unit **314**, and obtains information indicating an inter prediction mode, motion vector information, and the like from the motion prediction/compensation unit **315**. The lossless encoding unit **306** further obtains the filter coefficient and the like used at the loop filter **311**.

The lossless encoding unit **306** encodes those various kinds of information by an appropriate encoding method, and incorporates the information into (or multiplexes the information with) the header information of the encoded data. The lossless encoding unit **306** supplies the encoded data obtained through the encoding to the accumulation buffer **307** to accumulate the encoded data.

The encoding method used by the lossless encoding unit **306** may be variable-length encoding or arithmetic encoding, for example. The variable-length encoding may be CAVLC (Context-Adaptive Variable Length Coding) specified in H.264/AVC, for example. The arithmetic encoding may be CABAC (Context-Adaptive Binary Arithmetic Coding), for example.

The accumulation buffer **307** temporarily holds the encoded data supplied from the lossless encoding unit **306**. The accumulation buffer **307** outputs the encoded data held therein to a recording device (a recording medium) or a transmission path or the like (not shown) in a later stage, for example, at a predetermined time.

The transform coefficient quantized at the quantization unit **305** is also supplied to the inverse quantization unit **308**. The inverse quantization unit **308** inversely quantizes the quantized transform coefficient by a method compatible with the quantization performed by the quantization unit **305**. The inverse quantization method may be any method as long as the method is compatible with the quantization operation performed by the quantization unit **305**. The inverse quantization unit **308** supplies the obtained transform coefficient to the inverse orthogonal transform unit **309**.

The inverse orthogonal transform unit **309** performs an inverse orthogonal transform on the transform coefficient supplied from the inverse quantization unit **308**, by a method compatible with the orthogonal transform operation performed by the orthogonal transform unit **304**. This inverse orthogonal transform may be performed by any method as long as the method is compatible with the orthogonal transform operation performed by the orthogonal transform unit **304**. The output subjected to the inverse orthogonal transform (the restored difference information) is supplied to the arithmetic operation unit **310**.

The arithmetic operation unit **310** obtains a locally decoded image (a decoded image) by adding the predicted image supplied from the intra prediction unit **314** or the motion prediction/compensation unit **315** via the selection unit **316** to the inverse orthogonal transform result supplied from the inverse orthogonal transform unit **309** or the restored difference information.

For example, when the difference information corresponds to an image to be intra-encoded, the arithmetic operation unit **310** adds the predicted image supplied from the intra prediction unit **314** to the difference information. When the difference information corresponds to an image to be inter-encoded, the arithmetic operation unit **310** adds the predicted image supplied from the motion prediction/compensation unit **315** to the difference information, for example.

The addition result (a decoded image) is supplied to the loop filter **311** or the frame memory **312**.

The loop filter **311** includes a deblocking filter, an adaptive loop filter, and the like, and, where appropriate, performs a filtering operation on the decoded image supplied from the arithmetic operation unit **310**. For example, the loop filter **311** removes block distortions from the decoded image by performing, on the decoded image, the same deblocking filtering operation as that performed by the deblocking filter **111**. Also, the loop filter **311** improves image quality by performing a loop filtering operation using a Wiener filter on the result of the deblocking filtering operation (the decoded image from which block distortions have been removed).

Alternatively, the loop filter **311** may perform any appropriate filtering operation on the decoded image. Also, the loop filter **311** can supply the information such as the filter coefficient used in the filtering operation to the lossless encoding unit **306** to encode the information, where necessary.

The loop filter **311** supplies the result of the filtering operation (the decoded image after the filtering operation) to the frame memory **312**. As described above, the decoded image that is output from the arithmetic operation unit **310** can be supplied to the frame memory **312** without passing through the loop filter **311**. That is, the filtering operation by the loop filter **311** may be skipped.

The frame memory **312** stores the supplied decoded image, and supplies the stored decoded image as a reference image to the selection unit **313** at a predetermined time.

The selection unit **313** selects a supply destination of the reference image supplied from the frame memory **312**. In the case of an intra prediction, for example, the selection unit **313** supplies the reference image supplied from the frame memory **312**, to the intra prediction unit **314**. In the case of an inter prediction, for example, the selection unit **313** supplies the reference image supplied from the frame memory **312**, to the motion prediction/compensation unit **315**.

The intra prediction unit **314** performs intra predictions (intra-screen predictions) to generate a predicted image by using the pixel values in the current picture that is the reference image supplied from the frame memory **312** via the selection unit **313**. In the generation of the predicted image, a PU is used basically as a unit of processing. The intra prediction unit **314** performs intra predictions in more than one mode (intra prediction modes) that is prepared in advance. The intra prediction unit **314** can perform the intra predictions not only in the modes specified by the AVC encoding method but also in any other appropriate modes.

The intra prediction unit **314** generates predicted images in all the candidate intra prediction modes, evaluates the cost function values of the respective predicted images by using the input image supplied from the screen rearrangement buffer **102**, and selects an optimum mode. After selecting the optimum intra prediction mode, the intra prediction unit **314** supplies the predicted image generated in the optimum intra prediction mode to the selection unit **316**.

As described above, the intra prediction unit **314** also supplies the intra prediction mode information indicating the adopted intra prediction mode, to the lossless encoding unit **306** to encode the intra prediction mode information, where appropriate.

Using the input image supplied from the screen rearrangement buffer **302**, and the reference image supplied from the frame memory **312** via the selection unit **313**, the motion prediction/compensation unit **315** performs motion predictions (inter predictions), and performs a motion compensation operation in accordance with the detected motion vectors, to generate a predicted image (inter predicted image information). In the motion predictions, a PU is used basically as a unit of processing. The motion prediction/compensation unit **315** performs such inter predictions in more than one mode (inter prediction modes) that is prepared in advance. The motion prediction/compensation unit **315** can perform the inter predictions not only in the modes specified by the AVC encoding method but also in any other appropriate modes.

The motion prediction/compensation unit **315** generates predicted images in all the candidate inter prediction modes, evaluates the cost function values of the respective predicted images, and selects an optimum mode. After selecting the optimum inter prediction mode, the motion prediction/compensation unit **315** supplies the predicted image generated in the optimum intra prediction mode to the selection unit **316**.

When the information indicating the selected inter prediction mode and encoded data are decoded, the motion prediction/compensation unit **315** supplies the necessary information for performing operations in the inter prediction mode, to the lossless encoding unit **306** to encode the information.

The selection unit **316** selects the supplier of the predicted image to be supplied to the arithmetic operation unit **303** and the arithmetic operation unit **310**. In the case of intra encoding, for example, the selection unit **316** selects the intra prediction unit **314** as the supplier of a predicted image, and supplies the predicted image supplied from the intra prediction unit **314**, to the arithmetic operation unit **303** and the arithmetic operation unit **310**. In the case of inter encoding, for example, the selection unit **316** selects the motion prediction/compensation unit **315** as the supplier of a predicted image, and supplies the predicted image supplied from the motion prediction/compensation unit **315**, to the arithmetic operation unit **303** and the arithmetic operation unit **310**.

Based on the bit rate of the encoded data accumulated in the accumulation buffer **307**, the rate control unit **317** controls the quantization operation rate of the quantization unit **305** so as not to cause an overflow or underflow.

The assignment control unit **321** controls assignment of a bit sequence (binarized data) to the predicted motion vector select information (pmv_index) indicating the adopted (selected) predicted motion vector at the lossless encoding unit **306**. The assignment control unit **321** controls the assignment of a bit sequence (binarized data) in accordance with the distance between the current picture and the anchor picture in terms of displaying order.

[Bit Sequence Assignment Control]

Next, the assignment control by the assignment control unit **321** is described.

FIG. **11** is a diagram for explaining example candidate predicted motion vectors (PMVs) in AMVP. In FIG. **11**, x is the current block. MV_A, MV_B, MV_C, MV_D, and MV_E are motion vectors (MVs) around the current block of the current picture, and are spatial_pmv. MV_Tmp is the MV of a co-located block located in the same position as x in an encoded picture, and is temporal_pmv. The anchor picture is normally the encoded picture that is the closest to the current picture on the L**1** side.

FIG. **12** is a diagram showing an example motion vector correlation in a case where the POC (Picture Order Count) difference dPOC between the current picture and the anchor picture is 2. In the diagram, t+4 is the POC of the current picture, and t+6 is the POC of the anchor picture. The bold line in the current picture represents the current block. The motion vectors (MVs) around the current block are spatial_pmv. In this diagram, one of the motion vectors is shown as MV_B. The bold line in the anchor picture indicates the co-located block. The motion vector MV_Tmp is temporal_pmv.

FIG. **13** is a diagram showing an example motion vector correlation in a case where the POC difference dPOC between the current picture and the anchor picture is 1.

As can be seen from a comparison between the example shown in FIG. **12** and the example shown in FIG. **13**, temporal_pmv (MV_Tmp) is closer to spatial_pmv (MV_B) in the example shown in FIG. **13** than in the example shown in FIG. **12**. That is, the smaller the dPOC, the higher the temporal_pmv prediction accuracy.

In view of this, when the dPOC is small, the assignment control unit **321** assigns a short bit sequence to temporal_pmv, and, when the dPOC is large, the assignment control unit **321** assigns a short bit sequence to spatial_pmv. By controlling the bit sequence assignment in the above manner, the assignment control unit **321** can reduce the bit rate of the predicted motion vector select information (pmv_index) for designating a candidate PMV having a high possibility to achieve high prediction accuracy.

[Lossless Encoding Unit and Assignment Control Unit]

FIG. **14** is a block diagram showing typical example structures of the lossless encoding unit **306** and the assignment control unit **321** shown in FIG. **10**.

As shown in FIG. **14**, the lossless encoding unit **306** includes a motion vector storage unit **331**, a predicted motion vector selection unit **332**, a difference motion vector calculation unit **333**, a table storage unit **334**, a binarization unit **335**, a binarization unit **336**, and an entropy encoding unit **337**.

The assignment control unit **321** includes a distance threshold acquirement unit **341**, a distance calculation unit **342**, and a table selection unit **343**.

The motion vector storage unit **331** stores the motion vector of the current PU to be processed. The motion vector of the current PU is contained in optimum mode information supplied from the motion prediction/compensation unit **315**. In an operation to be performed for another region in a later stage in terms of time, the motion vector storage unit **331** supplies stored motion vectors as candidate predicted motion vectors to the predicted motion vector selection unit **332**.

The predicted motion vector selection unit **332** acquires the motion vectors stored in the motion vector storage unit **331**, as the candidate predicted motion vectors, and selects, from the candidate predicted motion vectors, the motion vector closest to the motion vector of the current PU contained in the optimum mode information supplied from the motion prediction/compensation unit **315**, as the predicted motion vector. The predicted motion vector selection unit **332** supplies the selected motion vector as the predicted motion vector to the difference motion vector calculation unit **333**. The predicted motion vector selection unit **332** also supplies predicted motion vector select information indicating which candidate predicted motion vector has been selected as the predicted motion vector, to the binarization unit **335**.

The difference motion vector calculation unit **333** calculates a difference motion vector that is the difference between the predicted motion vector supplied from the predicted motion vector selection unit **332** and the motion vector of the current PU contained in the optimum mode information supplied from the motion prediction/compensation unit **315**. The difference motion vector calculation unit **333** supplies the calculated difference motion vector to the binarization unit **336**.

The table storage unit **334** stores table information that designates the bit sequence (binarized data) to be assigned to the predicted motion vector select information in accordance with the type of the vector selected as the predicted motion vector. The table storage unit **334** stores different sets of table information indicating different methods of bit sequence assignment in accordance with the types of vectors.

FIG. **15** is a diagram showing an example of the table information.

In the table information in FIG. **15**, the bit sequence column shows the values of the bit sequences to be assigned. The S**1** column shows the type of predicted motion vectors to which the respective bit sequences are to be assigned. The S**2** column is the same as the S**1** column, but differs from the S**1** column in the correspondence relationship with the bit sequences.

According to the assignment pattern of S**1**, for example, when the predicted motion vector is the median value (Median) (spatial_pmv) of MV_A, MV_B, and MV_C, the bit sequence "1" of 1 bin in code length is assigned. When the predicted motion vector is MV_A, the bit sequence "010" of 3 bins in code length is assigned. Likewise, when the predicted motion vector is MV_B, the bit sequence "011" of 3 bins in code length is assigned. When the predicted motion vector is MV_C, the bit sequence "00100" of 5 bins in code length is assigned. When the predicted motion vector is MV_E, the bit sequence "00101" of 5 bins in code length is assigned. When the predicted motion vector is MV_D, the bit sequence "00110" of 5 bins in code length is assigned.

When the predicted motion vector is MV_Tmp (temporal_pmv), the bit sequence "00111" of 5 bins in code length is assigned.

That is, in the case of **S1**, a shorter bit sequence is assigned to spatial_pmv, and a longer bit sequence is assigned to temporal_pmv.

According to the assignment pattern of **S2**, on the other hand, when the predicted motion vector is MV_Tmp (temporal_pmv), the bit sequence "1" of 1 bin in code length is assigned, for example.

When the predicted motion vector is the median value (Median) (spatial_pmv) of MV_A, MV_B, and MV_C, the bit sequence "010" of 3 bins in code length is assigned. When the predicted motion vector is MV_A, the bit sequence "011" of 3 bins in code length is assigned. Likewise, when the predicted motion vector is MV_B, the bit sequence "00100" of 5 bins in code length is assigned. When the predicted motion vector is MV_C, the bit sequence "00101" of 5 bins in code length is assigned. When the predicted motion vector is MV_E, the bit sequence "00110" of 5 bins in code length is assigned. When the predicted motion vector is MV_D, the bit sequence "00111" of 5 bins in code length is assigned.

That is, in this case, a longer bit sequence is assigned to spatial_pmv, and a shorter bit sequence is assigned to temporal_pmv.

Referring back to FIG. **14**, the table storage unit **334** stores different sets of table information showing different correspondence relationships, such as a table containing the "bit sequence" column and the "**S1**" column, and a table containing the "bit sequence" column and the "**S2**" column.

The code numbers shown in the example in FIG. **15** are virtual information for identifying the respective bit sequences, and therefore, have any values.

Although the table storage unit **334** stores sets of table information in the above description, more than one pattern should be prepared for assignment of bit sequences to the types of predicted motion vectors, and the assignment patterns of the respective bit sequences may be put into a single set of table information as shown in the example in FIG. **15**.

The binarization unit **335** shown in FIG. **14** refers to the table information of the assignment pattern (Sn) that is stored in the table storage unit **334** and is selected by the table selection unit **343** of the assignment control unit **321**, and, in accordance with the assignment pattern, binarizes the predicted motion vector select information (pmv_index) supplied from the predicted motion vector selection unit **332** (or transforms the predicted motion vector select information into the bit sequence assigned according to the table information). After the binarization, the binarization unit **335** supplies the binarized data to the entropy encoding unit **337**.

The binarization unit **336** binarizes various kinds of information, such as the quantized coefficient data supplied from the quantization unit **305**, the optimum mode information (such as the intra prediction mode information) supplied from the intra prediction unit **314**, and filter information (containing the filter coefficient and the like) supplied from the loop filter **311**, and supplies the binarized data to the entropy encoding unit **337**.

The binarization unit **336** also binarizes the optimum mode information supplied from the motion prediction/compensation unit **315**, and supplies the binarized data to the entropy encoding unit **337**.

The binarization unit **336** further binarizes the difference motion vector supplied from the difference motion vector calculation unit **333**, and supplies the binarized data to the entropy encoding unit **337**.

The binarization unit **336** also binarizes a distance threshold dPOC_th supplied from the distance threshold acquirement unit **341** of the assignment control unit **321**, and supplies the binarized data to the entropy encoding unit **337**.

The entropy encoding unit **337** encodes the respective sets of binarized data supplied from the binarization unit **335** and the binarization unit **336**, generates information such as header information where necessary, combines the respective sets of information, and supplies the combined information as a stream to the accumulation buffer **307** to accumulate the information.

The distance threshold acquirement unit **341** acquires the distance threshold dPOC_th from outside. This distance threshold dPOC_th is a threshold value for the assignment control unit **321** to control the bit sequence assignment pattern in accordance with the POC difference dPOC between the current picture and the anchor picture, or the distance between the current picture and the anchor picture in terms of displaying order.

This distance threshold dPOC_th may be set in any appropriate manner. For example, the distance threshold dPOC_th may be set in accordance with an instruction from a user, may be determined in accordance with the processing capability of the image encoding device **300**, or may be set in accordance with the contents of the image.

After acquiring the distance threshold dPOC_th, which has been determined in some manner, from outside, the distance threshold acquirement unit **341** supplies the distance threshold dPOC_th to the table selection unit **343**, so that the distance threshold dPOC_th is used in selecting a table (or selecting an assignment pattern).

The distance threshold acquirement unit **341** also supplies the acquired distance threshold dPOC_th to the binarization unit **336** of the lossless encoding unit **306**, so that the distance threshold dPOC_th is supplied to the decoding side.

The distance calculation unit **342** counts the POC of each picture, and calculates the POC difference dPOC between the current picture and the anchor picture. The distance calculation unit **342** supplies the difference dPOC to the table selection unit **343**.

The table selection unit **343** compares the difference (distance) dPOC supplied from the distance calculation unit **342** with the distance threshold dPOC_th supplied from the distance threshold acquirement unit **341**, and, in accordance with the comparison result, selects a table (a bit sequence assignment pattern) Sn.

In the example case shown in FIG. **15**, when the distance dPOC is longer than the distance threshold dPOC_th (or when the distance dPOC is equal to or longer than the distance threshold dPOC_th), spatial_pmv is prioritized, and accordingly, the table selection unit **343** selects **S1**, so that a shorter bit sequence is assigned to spatial_pmv. When the distance dPOC is equal to or shorter than the distance threshold dPOC_th (or when the distance dPOC is shorter than the distance threshold dPOC_th), temporal_pmv is prioritized, and accordingly, the table selection unit **343** selects S2, so that a shorter bit sequence is assigned to temporal_pmv.

The table selection unit **343** supplies the selection result Sn to the binarization unit **335** of the lossless encoding unit **306**.

As described above, the assignment control unit **321** can appropriately control the bit sequence assignment in accordance with the distance (dPOC) between the current picture and the anchor picture in terms of displaying order. That is, the assignment control unit **321** can assign a bit sequence having a shorter code length to the selection information about a motion vector having a higher designation frequency. In other words, the assignment control unit **321** can assign a bit sequence having a longer code length to the selection information about a motion vector having a lower designation frequency. Accordingly, the lossless encoding unit **306** can reduce the bit rate of the predicted motion vector select information (pmv_index). In this manner, the image encoding device **300** can increase encoding efficiency.

[Encoding Operation Flow]

Next, the flow of each operation to be performed by the above described image encoding device **300** is described. Referring first to the flowchart shown in FIG. **16**, an example flow of an encoding operation is described.

There are cases where the processing data units in the respective steps differ from one another. Therefore, in practice, the procedures of the respective steps might be carried out in parallel, or the sequence of the procedures might be changed. The same applies to the other operations described later.

In step S**301**, the A/D converter **301** performs an A/D conversion on input images. In step S**302**, the screen rearrangement buffer **302** stores the images subjected to the A/D conversion, and rearranges the respective pictures in encoding order, instead of displaying order.

In step S**303**, the intra prediction unit **314** performs intra prediction operations in intra prediction modes. In step S**304**, the motion prediction/compensation unit **315** performs inter motion prediction operations to perform motion predictions and motion compensation in inter prediction modes.

In step S**305**, the selection unit **316** determines an optimum mode based on the respective cost function values that are output from the intra prediction unit **314** and the motion prediction/compensation unit **315**. That is, the selection unit **316** selects the predicted image generated by the intra prediction unit **314** or the predicted image generated by the motion prediction/compensation unit **315**.

The selection information indicating which predicted image has been selected is supplied to the intra prediction unit **314** or the motion prediction/compensation unit **315**, whichever has generated the selected predicted image. When the predicted image generated in the optimum intra prediction mode is selected, the intra prediction unit **314** supplies the intra prediction mode information indicating the optimum intra prediction mode and the like to the lossless encoding unit **306**. When the predicted image generated in the optimum inter prediction mode is selected, the motion prediction/compensation unit **315** outputs the information indicating the optimum inter prediction mode to the lossless encoding unit **306**.

In step S**306**, the arithmetic operation unit **303** calculates the difference between the images rearranged in the procedure of step S**302** and the predicted image selected in the procedure of step S**305**. The predicted image is supplied to the arithmetic operation unit **303** via the selection unit **316** from the motion prediction/compensation unit **315** when an inter prediction is performed, and from the intra prediction unit **314** when an intra prediction is performed.

The data amount of the difference data is smaller than that of the original image data. Accordingly, the data amount can be made smaller than in a case where images are directly encoded.

In step S**307**, the orthogonal transform unit **304** performs an orthogonal transform on the difference information generated in the procedure of step S**306**. Specifically, an orthogonal transform such as a discrete cosine transform or a Karhunen-Loeve transform is performed, and a transform coefficient is output.

In step S**308**, the quantization unit **305** quantizes the orthogonal transform coefficient obtained in the procedure of step S**307**.

The difference information quantized in the procedure of step S**308** is locally decoded in the following manner. In step S**309**, the inverse quantization unit **308** inversely quantizes the quantized orthogonal transform coefficient (also referred to as the quantized coefficient) generated in the procedure of step S**308**, using properties compatible with the properties of the quantization unit **305**. In step S**310**, the inverse orthogonal transform unit **309** performs an inverse orthogonal transform on the orthogonal transform coefficient obtained in the procedure of step S**307**, using properties compatible with the properties of the orthogonal transform unit **304**.

In step S**311**, the arithmetic operation unit **310** adds the predicted image to the locally decoded difference information, and generates a locally decoded image (an image corresponding to the input to the arithmetic operation unit **303**). In step S**312**, the loop filter **311** performs a loop filtering operation including a deblocking filtering operation and an adaptive loop filtering operation on the locally decoded image obtained in the procedure of step S**311**, where appropriate.

In step S**313**, the frame memory **312** stores the decoded image subjected to the loop filtering operation in the procedure of step S**312**. Images that are not subjected to filtering operations by the loop filter **311** are also supplied from the arithmetic operation unit **310**, and are stored into the frame memory **312**.

In step S**314**, the lossless encoding unit **306** encodes the transform coefficient quantized in the procedure of step S**308**. That is, lossless encoding such as variable-length encoding or arithmetic encoding is performed on the difference image.

The lossless encoding unit **306** also encodes the quantization parameter calculated in step S**308**, and adds the encoded quantization parameter to the encoded data. The lossless encoding unit **306** also encodes the information about the mode of the predicted image selected in the procedure of step S**305**, and adds the encoded information to the encoded data obtained by encoding the difference image. That is, the lossless encoding unit **306** also encodes the optimum intra prediction mode information supplied from the intra prediction unit **314** or the optimum inter prediction mode supplied from the motion prediction/compensation unit **315**, and adds the encoded information to the encoded data.

In step S**315**, the accumulation buffer **307** accumulates the encoded data that is output from the lossless encoding unit **306**. The encoded data accumulated in the accumulation buffer **307** is read where appropriate, and is transmitted to the decoding side via a transmission path or a recording medium.

In step S**316**, based on the bit rate (bit generation rate) of the encoded data that is accumulated in the accumulation buffer **307** in the procedure of step S**315**, the rate control unit **317** controls the quantization operation rate of the quantization unit **305** so as not to cause an overflow or underflow.

When the procedure of step S**316** is completed, the encoding operation comes to an end.

[Lossless Encoding Operation Flow]

Referring now to the flowchart shown in FIG. **17**, an example flow of the lossless encoding operation performed in step S**314** of FIG. **16** is described.

When the lossless encoding operation is started, the binarization unit **336** and the entropy encoding unit **337** binarize and encode the quantized coefficient data in step S**321**, binarize and encode the filter information in step S**3322**, and binarize and encode the intra prediction mode information about the intra-encoded region in step S**323**.

In step S**324**, the lossless encoding unit **306** and the assignment control unit **321** binarize and encode the inter prediction mode information about the inter-encoded region.

In step S**325**, the entropy encoding unit **337** combines the respective sets of encoded data into a stream.

After the procedure of step S**325** is completed, the entropy encoding unit **337** ends the lossless encoding operation. The operation then returns to step S**314** of FIG. **16**, and moves on to step S**315**.

[Flow of the Inter Prediction Mode Information Encoding Operation]

Referring now to the flowchart shown in FIG. **18**, an example flow of the inter prediction mode information encoding operation performed in step S**324** of FIG. **17** is described.

When the inter prediction mode information encoding operation is started, the distance threshold acquirement unit **341** acquires the distance threshold dPOC_th in step S**331**. In step S**332**, the binarization unit **336** and the entropy encoding unit **337** binarize and encode the distance threshold dPOC_th acquired in step S**331**, and store the encoded distance threshold dPOC_th into the sequence parameter set (SPS).

In step S**333**, the motion vector storage unit **331** stores the motion vector of the current PU contained in the optimum mode information (inter prediction mode information). In step S**334**, the predicted motion vector selection unit **332** acquires the peripheral motion vectors stored in the motion vector storage unit **331**, as candidate predicted motion vectors. In step S**335**, the predicted motion vector selection unit **332** selects the candidate predicted motion vector closest to the motion vector of the current PU, as the predicted motion vector.

In step S**336**, the distance calculation unit **342** calculates the distance dPOC between the current picture and the anchor picture. In step S**337**, the table selection unit **343** selects the table information indicating a bit sequence assignment pattern, in accordance with the magnitude relationship between the distance dPOC determined in step S**336** and the distance threshold dPOC_th acquired in step S**331**.

In step S**338**, the binarization unit **335** refers to the table information that is stored in the table storage unit **334** and has been selected in step S**337**, and binarizes the predicted motion vector select information indicating which candidate predicted motion vector has been selected in step S**335**. In step S**339**, the entropy encoding unit **337** encodes the binarized data of the predicted motion vector select information binarized in step S**338**.

In step S**340**, the difference motion vector calculation unit **333** determines the difference motion vector that is the difference between the current motion vector and the predicted motion vector. In step S**341**, the binarization unit **336** and the entropy encoding unit **337** binarize and encode the difference motion vector acquired in step S**340**.

In step S**342**, the binarization unit **336** and the entropy encoding unit **337** binarize and encode other optimum mode information.

After the procedure of step S**342** is completed, the entropy encoding unit **337** ends the inter prediction mode information encoding operation. The operation then returns to step S**324** of FIG. **17**, and moves on to step S**325**.

As the respective operations are performed in the above described manner, the assignment control unit **321** can appropriately control the bit sequence assignment in accordance with the distance (dPOC) between the current picture and the anchor picture in terms of displaying order. That is, the assignment control unit **321** can assign a bit sequence having a shorter code length to the selection information about a motion vector having a higher designation frequency. In other words, the assignment control unit **321** can assign a bit sequence having a longer code length to the selection information about a motion vector having a lower designation frequency. Accordingly, the lossless encoding unit **306** can reduce the bit rate of the predicted motion vector select information (pmv_index). In this manner, the image encoding device **300** can increase encoding efficiency.

[Image Decoding Device]

FIG. **19** is a block diagram showing a typical example structure of an image decoding device. The image decoding device **400** shown in FIG. **19** is a decoding device that is compatible with the image encoding device **300** shown in FIG. **10**. Data encoded by the image encoding device **300** is supplied to the image decoding device **400** via a passage such as a transmission path or a recording medium, and is then decoded.

As shown in FIG. **19**, the image decoding device **400** includes an accumulation buffer **401**, a lossless decoding unit **402**, an inverse quantization unit **403**, an inverse orthogonal transform unit **404**, an arithmetic operation unit **405**, a loop filter **406**, a screen rearrangement buffer **407**, and a D/A converter **408**. The image decoding device **400** also includes a frame memory **409**, a selection unit **410**, an intra prediction unit **411**, a motion prediction/compensation unit **412**, and a selection unit **413**.

The image decoding device **400** further includes an assignment control unit **421**.

The accumulation buffer **401** accumulates transmitted encoded data. The encoded data has been encoded by the image encoding device **300**. The lossless decoding unit **402** reads the encoded data from the accumulation buffer **401** at a predetermined time, and decodes the encoded data by a method compatible with the encoding method used by the lossless encoding unit **306** shown in FIG. **10**.

When the current frame is an intra-encoded frame, the header portion of the encoded data stores intra prediction mode information. The lossless decoding unit **402** also decodes the intra prediction mode information, and supplies the resultant information to the intra prediction unit **411**. When the current frame is an inter-encoded frame, on the other hand, the header portion of the encoded data stores motion vector information and inter prediction mode information. The lossless decoding unit **402** also decodes the motion vector information and the inter prediction mode information, and supplies the resultant information to the motion prediction/compensation unit **412**.

The inverse quantization unit **403** inversely quantizes the coefficient data (the quantized coefficient) decoded by the lossless decoding unit **402**, by a method compatible with the quantization method used by the quantization unit **305** shown in FIG. **10**. That is, the inverse quantization unit **403** inversely quantizes the quantized coefficient by the same method as the method used by the inverse quantization unit **308** shown in FIG. **10**.

The inverse quantization unit **403** supplies the inversely-quantized coefficient data, or the orthogonal transform coefficient, to the inverse orthogonal transform unit **404**. The inverse orthogonal transform unit **404** performs an inverse orthogonal transform on the orthogonal transform coefficient by a method compatible with the orthogonal transform method used by the orthogonal transform unit **304** shown in FIG. **10** (or by the same method as that used by the inverse orthogonal transform unit **309** shown in FIG. **10**). The inverse orthogonal transform unit **404** obtains decoded residual error data equivalent to the residual error data from the time prior to the orthogonal transform in the image encoding device **300**. For example, a fourth-order inverse orthogonal transform is performed.

The decoded residual error data obtained through the inverse orthogonal transform is supplied to the arithmetic operation unit **405**. A predicted image is also supplied to the arithmetic operation unit **405** from the intra prediction unit **411** or the motion prediction/compensation unit **412** via the selection unit **413**.

The arithmetic operation unit **405** adds the decoded residual error data to the predicted image, and obtains decoded image data corresponding to the image data from the time prior to the predicted image subtraction performed by the arithmetic operation unit **303** of the image encoding device **300**. The arithmetic operation unit **405** supplies the decoded image data to the loop filter **406**.

The loop filter **406** performs a loop filtering operation including a deblocking filtering operation and an adaptive loop filtering operation on the supplied decoded image, where appropriate, and supplies the resultant decoded image to the screen rearrangement buffer **407**.

The loop filter **406** includes a deblocking filter, an adaptive loop filter, and the like, and, where appropriate, performs a filtering operation on the decoded image supplied from the arithmetic operation unit **405**. For example, the loop filter **406** removes block distortions from the decoded image by performing a deblocking filtering operation on the decoded image. Also, the loop filter **406** improves image quality by performing a loop filtering operation using a Wiener filter on the result of the deblocking filtering operation (the decoded image from which block distortions have been removed).

Alternatively, the loop filter **406** may perform any appropriate filtering operation on the decoded image. The loop filter **406** may also perform a filtering operation by using the filter coefficient supplied from the image encoding device **300** shown in FIG. **10**.

The loop filter **406** supplies the result of the filtering operation (the decoded image after the filtering operation) to the screen rearrangement buffer **407** and the frame memory **409**. The decoded image that is output from the arithmetic operation unit **405** can be supplied to the screen rearrangement buffer **407** and the frame memory **409** without passing through the loop filter **406**. That is, the filtering operation by the loop filter **406** may be skipped.

The screen rearrangement buffer **407** performs image rearrangement. Specifically, the frame sequence rearranged in the encoding order by the screen rearrangement buffer **302** shown in FIG. **10** is rearranged in the original displaying order. The D/A converter **408** performs a D/A conversion on the images supplied from the screen rearrangement buffer **407**, and outputs the converted images to a display (not shown) to display the images.

The frame memory **409** stores the supplied decoded image, and supplies the stored decoded image as a reference image to the selection unit **410** at a predetermined time or in response to an external request from the intra prediction unit **411** or the motion prediction/compensation unit **412** or the like.

The selection unit **410** selects a supply destination of the reference image supplied from the frame memory **409**. When an intra-encoded image is decoded, the selection unit **410** supplies the reference image supplied from the frame memory **409**, to the intra prediction unit **411**. When an inter-encoded image is decoded, the selection unit **410** supplies the reference image supplied from the frame memory **409**, to the motion prediction/compensation unit **412**.

Information that has been obtained by decoding the header information and indicates an intra prediction mode or the like is supplied from the lossless decoding unit **402** to the intra prediction unit **411**, where appropriate. The intra prediction unit **411** performs intra predictions in the intra prediction modes used by the intra prediction unit **314** shown in FIG. **10**, by using the reference image acquired from the frame memory **409**. A predicted image is thus generated. Like the intra prediction unit **314** shown in FIG. **10**, the intra prediction unit **411** can perform the intra predictions not only in the modes specified by the AVC encoding method but also in any other appropriate modes.

The intra prediction unit **411** supplies the generated predicted image to the selection unit **413**.

The motion prediction/compensation unit **412** obtains, from the lossless decoding unit **402**, the information obtained by decoding the header information (optimum mode information, motion vector information, reference frame information, a flag, respective parameters, and the like).

The motion prediction/compensation unit **412** performs inter predictions in the inter prediction modes used by the motion prediction/compensation unit **315** shown in FIG. **10**, by using the reference image acquired from the frame memory **409**. A predicted image is thus generated. Like the motion prediction/compensation unit **315** shown in FIG. **10**, the motion prediction/compensation unit **412** can perform the intra predictions not only in the modes specified by the AVC encoding method but also in any other appropriate modes.

Like the motion prediction/compensation unit **212**, the motion prediction/compensation unit **412** supplies the generated predicted image to the selection unit **413**.

The selection unit **413** selects the supplier of the predicted image to be supplied to the arithmetic operation unit **405**. Specifically, the selection unit **413** supplies the predicted image generated by the motion prediction/compensation unit **412** or the intra prediction unit **411**, to the arithmetic operation unit **405**.

The assignment control unit **421** performs the same bit sequence assignment control as that performed in the image encoding device **300**, so as to correctly debinarize the binarized data of the predicted motion vector select information in the debinarization to be performed in the lossless decoding unit **402**.

[Lossless Decoding Unit and Assignment Control Unit]

FIG. **20** is a block diagram showing typical example structures of the lossless decoding unit **402** and the assignment control unit **421** shown in FIG. **19**.

As shown in FIG. **20**, the lossless decoding unit **402** includes an entropy decoding unit **431**, a debinarization unit **432**, a table storage unit **433**, a debinarization unit **434**, a predicted motion vector selection unit **435**, a motion vector calculation unit **436**, and a motion vector storage unit **437**.

The assignment control unit **421** includes a distance calculation unit **441** and a table selection unit **442**.

The entropy decoding unit **431** decodes a code stream supplied from the accumulation buffer **401**, and supplies the binarized data to the debinarization unit **432** and the debinarization unit **434**.

The debinarization unit **432** debinarizes the binarized data of various kinds of information supplied from the image encoding device **300**, such as the quantized coefficient data, the optimum mode information, the filter information, the difference motion vector, and the distance threshold dPOC_th. The debinarization unit **432** supplies the obtained coefficient data to the inverse quantization unit **403**. The debinarization unit **432** also supplies the obtained optimum mode information to the intra prediction unit **411** or the motion prediction/compensation unit **412**. The debinarization unit **432** further supplies the obtained filter information to the loop filter **406**. The debinarization unit **432** also supplies the obtained difference motion vector to the motion vector calculation unit **436**. The debinarization unit **432** further supplies the obtained distance threshold dPOC_th to the table selection unit **442** of the assignment control unit **421**.

The table storage unit **433** stores table information that indicates bit sequence assignment patterns for predicted motion vector select information, like the table information stored in the table storage unit **334** of the image encoding device **300** as shown in FIG. **15**, for example. Like the table storage unit **334**, the table storage unit **433** stores more than one set of table information (S**1** and S**2**, for example) indicating different assignment patterns from each other. The table information may be put into one table as in the case of the table storage unit **334**.

The debinarization unit **434** refers to table information Sn that is stored in the table storage unit **433** and has been selected by the table selection unit **442** of the assignment control unit **421**, and, in accordance with the assignment pattern, debinarizes the binarized data of the predicted motion vector select information supplied from the entropy decoding unit **431**. The debinarization unit **434** supplies the predicted motion vector select information obtained through the debinarization to the predicted motion vector selection unit **435**.

The predicted motion vector selection unit **435** acquires the motion vectors (peripheral motion vectors) that are located around the current PU and are stored in the motion vector storage unit **437**, as candidate predicted motion vectors. From the candidate predicted motion vectors, the predicted motion vector selection unit **435** selects the candidate predicted motion vector indicated by the predicted motion vector select information supplied from the debinarization unit **434**, as the predicted motion vector. The predicted motion vector selection unit **435** supplies the selected predicted motion vector to the motion vector calculation unit **436**.

The motion vector calculation unit **436** calculates the motion vector of the current PU by adding the predicted motion vector supplied from the predicted motion vector selection unit **435** to the difference motion vector supplied from the debinarization unit **432**. The motion vector calculation unit **436** supplies the calculated motion vector to the motion prediction/compensation unit **412**. The motion vector calculation unit **436** also supplies and stores the calculated motion vector into the motion vector storage unit **437**.

The motion vectors stored in the motion vector storage unit **437** are used as the peripheral motion vectors (the candidate predicted motion vectors) in operations to be performed for regions to be processed in later stages than the current PU in terms of time.

The distance calculation unit **441** of the assignment control unit **421** counts the POC of each picture, and calculates the POC difference dPOC between the current picture and the anchor picture. The distance calculation unit **441** supplies the difference dPOC to the table selection unit **442**.

The table selection unit **442** compares the difference dPOC supplied from the distance calculation unit **441** with the distance threshold dPOC_th that is supplied from the debinarization unit **432** and has been used at the time of encoding, and, in accordance with the comparison result, selects a table (a bit sequence assignment pattern) Sn. The table selection unit **442** supplies the selection result Sn to the debinarization unit **434** of the lossless encoding unit **306**.

As described above, as the assignment control unit **421** appropriately controls the bit sequence assignment in accordance with the distance (dPOC) between the current picture and the anchor picture in terms of displaying order, the lossless decoding unit **402** can reproduce the same bit sequence assignment as that used in the encoding, and correctly decode the encoded data supplied from the image encoding device **300**. In short, the image decoding device **400** can increase encoding efficiency.

[Decoding Operation Flow]

Next, the flow of each operation to be performed by the above described image decoding device **400** is described. Referring first to the flowchart shown in FIG. **21**, an example flow of a decoding operation is described.

When the decoding operation is started, the accumulation buffer **401** accumulates transmitted encoded data in step S**401**. In step S**402**, the lossless decoding unit **402** decodes the encoded data (encoded data generated by the image encoding device **300** encoding image data) supplied from the accumulation buffer **401**.

In step S**403**, the inverse quantization unit **403** inversely quantizes the quantized orthogonal transform coefficient obtained through the decoding performed by the lossless decoding unit **402**, by a method compatible with the quantization operation performed by the quantization unit **305** shown in FIG. **10**. In step S**404**, the inverse orthogonal transform unit **404** performs an inverse orthogonal transform on the orthogonal transform coefficient obtained through the inverse quantization performed by the inverse quantization unit **403**, by a method compatible with the orthogonal transform operation performed by the orthogonal transform unit **304** shown in FIG. **10**. As a result, the difference information corresponding to the input to the orthogonal transform unit **304** (or the output from the arithmetic operation unit **303**) shown in FIG. **10** is decoded.

In step S**405**, the intra prediction unit **411** and the motion prediction/compensation unit **412** perform prediction operations, and generate predicted images.

In step S**406**, the selection unit **413** selects a predicted image generated in the procedure of step S**405**. Specifically, the predicted image generated by the intra prediction unit **411**, or the predicted image generated by the motion prediction/compensation unit **412** is supplied to the selection unit **413**. The selection unit **413** selects the supplied predicted image, and supplies the predicted image to the arithmetic operation unit **405**.

In step S**407**, the arithmetic operation unit **405** adds the predicted image selected in step S**406** to the difference information obtained in the procedure of step S**404**. In this manner, the original image data is decoded.

In step S**408**, the loop filter **406** performs filtering on the decoded image obtained in the procedure of step S**407**, where appropriate.

In step S**409**, the screen rearrangement buffer **407** rearranges the frames of the decoded images appropriately subjected to the filtering in step S**408**. Specifically, the order of frames rearranged for encoding by the screen rearrangement buffer **302** of the image encoding device **300** (FIG. **10**) is rearranged in the original displaying order.

In step S**410**, the D/A converter **408** performs a D/A conversion on the decoded image data having the frames rearranged in step S**409**. The decoded image data is output to a display (not shown), and the images are displayed.

In step S411, the frame memory 409 stores the decoded images appropriately subjected to the filtering in step S408.

After the procedure of step S411 is completed, the frame memory 409 ends the decoding operation.

[Lossless Decoding Operation Flow]

Referring now to the flowchart shown in FIG. 22, an example flow of the lossless decoding operation performed in step S402 of FIG. 21 is described.

When the lossless decoding operation is started, the lossless decoding unit 402 and the assignment control unit 421 decode and debinarize the inter prediction mode information about the inter-encoded region in step S421.

The entropy decoding unit 431 and the debinarization unit 432 decode and debinarize the intra prediction mode information about the intra-encoded region in step S422, decode and debinarize the filter information in step S423, and decode and debinarize the coefficient data in step S424.

After the procedure of step S424 is completed, the debinarization unit 432 ends the lossless decoding operation. The operation then returns to step S402 of FIG. 21, and moves on to step S403.

[Flow of the Inter Prediction Mode Information Decoding Operation]

Referring now to the flowchart shown in FIG. 23, an example flow of the inter prediction mode information decoding operation performed in step S421 of FIG. 22 is described.

When the inter prediction mode information decoding operation is started, the entropy decoding unit 431 and the debinarization unit 432, in step S431, extract the encoded data of the distance threshold dPOC_th from the SPS, and decode and debinarize the extracted encoded data.

In step S432, the distance calculation unit 441 of the assignment control unit 421 calculates the distance dPOC between the current picture and the anchor picture.

In step S433, the table selection unit 442 of the assignment control unit 421 compares the distance dPOC between the current picture and the anchor picture calculated in step S432 with the threshold distance dPOC_th acquired in step S431, and selects the table information Sn to be used in debinarization in accordance with the magnitude relationship between the distance dPOC and the threshold distance dPOC_th.

In step S434, the entropy decoding unit 431 decodes the predicted motion vector select information.

In step S435, the debinarization unit 434 refers to the table that is stored in the table storage unit 433 and has been selected in step S433, and, in accordance with the bit sequence assignment pattern Sn, debinarizes the binarized data of the predicted motion vector select information obtained in step S434 (or transforms a bit sequence into information indicating the motion vector corresponding to the bit sequence).

In step S436, the predicted motion vector selection unit 435 acquires the peripheral motion vectors stored in the motion vector storage unit 437, as candidate predicted motion vectors.

In step S437, the predicted motion vector selection unit 435 selects, from the candidate predicted motion vectors obtained in step S436, the motion vector designated by the predicted motion vector select information obtained through the debinarization performed in step S435, and sets the selected motion vector as the predicted motion vector.

In step S438, the entropy decoding unit 431 and the debinarization unit 432 decode the encoded data of the difference motion vector, and debinarize the resultant binarized data, to obtain the difference motion vector.

In step S439, the motion vector calculation unit 436 calculates the motion vector of the current PU by adding the predicted motion vector selected in step S437 to the difference motion vector obtained in the procedure of step S438.

In step S440, the motion vector storage unit 437 stores the motion vector of the current PU obtained in the procedure of step S439.

In step S441, the entropy decoding unit 431 and the debinarization unit 432 decode the encoded data of other optimum mode information, and debinarize the resultant binarized data, to obtain the other optimum mode information.

After the procedure of step S441 is completed, the debinarization unit 432 ends the inter prediction mode information decoding operation. The operation then returns to step S421 of FIG. 22, and moves on to step S422.

As described above, by performing the respective operations, the lossless decoding unit 402 can reproduce the same bit sequence assignment as that used in the encoding, and correctly decode the encoded data supplied from the image encoding device 300. In short, the image decoding device 400 can increase encoding efficiency.

[Other Examples]

Although example bit sequence assignment patterns have been described with reference to FIG. 15, other bit sequence assignment methods may be used. For example, when the distance dPOC is equal to or shorter than the distance threshold dPOC_th (or when the distance dPOC is shorter than the distance threshold dPOC_th), S3 in the table information shown in FIG. 24 may be selected, instead of S2 in FIG. 15.

In the case of S3, the bit sequence to be assigned when the predicted motion vector MV_Tmp (temporal_pmv) and the bit sequence to be assigned when the predicted motion vector is the median value (Median) (spatial_pmv) of MV_A, MV_B, and MV_C are switched, compared with those in S1.

It is of course possible to prepare assignment patterns other than that.

In FIG. 15, exponential Golomb values are used as bit sequential values, but any values may be used as the bit sequential values, as long as those values can be distinguished from one another. For example, unary codes may be used as in the example table information shown in FIG. 25.

In the above description, the distance threshold dPOC_th has been described as a variable value, but the distance threshold dPOC_th may be a fixed value that is determined in advance. For example, the image encoding device 300 and the image decoding device 400 may share the distance threshold dPOC_th, which is a fixed value. In that case, the transmission and the reception of the distance threshold dPOC_th are skipped. Alternatively, the image encoding device 300 may supply the fixed distance threshold dPOC_th to the image decoding device 400 prior to transmission of encoded data. Further, the image decoding device 400 may supply the fixed distance threshold dPOC_th to the image encoding device 300 prior to encoding. Also, a device other than the image encoding device 300 and the image decoding device 400 may supply the fixed distance threshold dPOC_th to the image encoding device 300 and the image decoding device 400.

Also, more than one distance threshold dPOC_th may be prepared. In that case, three or more sets of table information (code sequence assignment patterns Sn) are prepared, and an appropriate pattern is selected in accordance with the magnitude relationship between the distance dPOC and the distance threshold dPOC_th.

The distance threshold dPOC_th can be stored in any position in a stream, other than the SPS. For example, the distance threshold dPOC_th may be stored in the picture parameter set (PPS) or the slice header. The distance threshold dPOC_th may also be stored in the SEI (Supplemental Enhancement Information) or the like.

Further, the optimum mode information may be transmitted to the decoding side, independently of encoded data.

Also, the distance threshold dPOC_th may be changed for each processing unit. For example, the distance threshold dPOC_th may be changed for each picture, may be changed for each slice, may be changed for each CU, or may be changed in some other manner.

<2. Second Embodiment>

[Lossless Encoding Unit and Assignment Control Unit]

In the above description, the bit sequence assignment pattern is controlled in accordance with the distance dPOC between the current picture and the anchor picture. However, the present invention is not limited to that, and the bit sequence assignment pattern may be controlled based on the similarity between peripheral motion vectors that are motion vectors of regions located around the current PU.

FIG. **26** is a block diagram showing typical example structures of the lossless encoding unit **306** and the assignment control unit **321** in such a case.

In the example case illustrated in FIG. **26**, the lossless encoding unit **306** has basically the same structure as that in the example case described with reference to FIG. **14**.

In this case, however, the assignment control unit **321** includes a similarity threshold acquirement unit **541**, a similarity calculation unit **542**, and a table selection unit **543**.

As in the case of the distance threshold dPOC_th, the similarity threshold acquirement unit **541** acquires a similarity threshold MV_th from outside. This similarity threshold MV_th is the threshold value for the assignment control unit **321** to control the bit sequence assignment pattern in accordance with the similarity between peripheral motion vectors.

Like the distance threshold dPOC_th, this similarity threshold MV_th may also be set in any appropriate manner. After acquiring the similarity threshold MV_th, which has been determined in some manner, from outside, the similarity threshold acquirement unit **541** supplies the similarity threshold MV_th to the table selection unit **543**, so that the similarity threshold MV_th is used in selecting a table (selecting an assignment pattern). The similarity threshold acquirement unit **541** also supplies the acquired similarity threshold MV_th to the binarization unit **336** of the lossless encoding unit **306**, so that the similarity threshold MV_th is supplied to the decoding side.

The similarity calculation unit **542** acquires, from the motion vector storage unit **331**, peripheral motion vectors that are the motion vectors of regions located around the current PU, and calculates the similarity between the peripheral motion vectors by comparing the peripheral motion vectors. In calculating the similarity, any peripheral motion vectors may be used. The similarity calculation unit **542** supplies the calculated similarity to the table selection unit **543**.

The table selection unit **543** compares the similarity supplied from the similarity calculation unit **542** with the similarity threshold MV_th supplied from the similarity threshold acquirement unit **541**, and, in accordance with the comparison result, selects a table (a bit sequence assignment pattern) Sn.

FIG. **27** shows an example case where the upper right peripheral motion vector (MV_TR) in the current region is similar to the lower left peripheral motion vector (MV_BL). In this case, the motion vector of the current region x is expected to be also similar to those peripheral motion vectors. Therefore, in the example case illustrated in FIG. **15**, the table selection unit **543** selects S**1**.

On the other hand, FIG. **28** shows an example case where the upper right peripheral motion vector (MV_TR) is not similar to the lower left peripheral motion vector (MV_BL). In this case, the motion vector of the current region x is determined not to be necessarily similar to those peripheral motion vectors. Therefore, in the example case illustrated in FIG. **15**, the table selection unit **543** selects S**2**.

There are cases where the region C and the region E have not been encoded, or are not inter prediction blocks. In view of this, the upper-right peripheral motion vector and the lower-left peripheral motion vector that are used in calculating a similarity may be peripheral motion vectors of other regions, as shown in FIGS. **29** through **31**.

For example, in a case where the peripheral motion vector MV_E is not available, the similarity between the motion vector MV_A of the region A and the motion vector MV_C of the region C may be calculated as shown in FIG. **29**. Also, in a case where the peripheral motion vector MV_C is not available, for example, the similarity between the motion vector MV_E of the region E and the motion vector MV_B of the region B may be calculated as shown in FIG. **30**. Further, in a case where the peripheral motion vector MV_E and the peripheral motion vector MV_C are not available, for example, the similarity between the motion vector MV_A of the region A and the motion vector MV_B of the region B may be calculated as shown in FIG. **31**. It is of course possible to use peripheral motion vectors other than the above. Which vector should be used instead may be acknowledged beforehand between the encoding side and the decoding side, and information indicating which vectors have been used may be transmitted and received.

The similarity between the upper-right peripheral motion vector (MV_TR) and the lower-left peripheral motion vector (MV_BL) is calculated as the absolute value of the vector difference |MV_TR−MV_BL|. When the absolute value is larger than the similarity threshold Myth, there is a high possibility that temporal_pmv is used, and therefore, a bit sequence of S**2** is selected.

Referring back to FIG. **26**, the table selection unit **543** supplies the selection result Sn to the binarization unit **335** of the lossless encoding unit **306**.

As described above, the assignment control unit **321** can appropriately control the bit sequence assignment in accordance with the similarity between peripheral motion vectors. That is, the assignment control unit **321** can also assign a bit sequence having a shorter code length to the selection information about a motion vector having a higher designation frequency in this case. In other words, the assignment control unit **321** can assign a bit sequence having a longer code length to the selection information about a motion vector having a lower designation frequency. Accordingly, the lossless encoding unit **306** can reduce the bit rate of the predicted motion vector select information (pmv_index). In this manner, the image encoding device **300** can increase encoding efficiency.

[Flow of the Inter Prediction Mode Information Encoding Operation]

Referring now to the flowchart shown in FIG. **32**, an example flow of the inter prediction mode information encoding operation in this case is described.

The operation to be performed in this case is also basically the same as the operation performed in the case where the distance threshold is used as described above with reference to the flowchart shown in FIG. **18**.

In step S**531**, however, the similarity threshold acquirement unit **541** acquires the similarity threshold MV_th, instead of the distance threshold. In step S**532**, the binarization unit **336** and the entropy encoding unit **337** binarize and encode the similarity threshold MV_th acquired in step S**531**, and store the similarity threshold MV_th into the SPS.

In step S533, the same procedure as step S333 is carried out. In step S534, the similarity calculation unit 542 acquires peripheral motion vectors. In step S535, the same procedure as step S335 is carried out.

In step S536, the similarity calculation unit 542 calculates the similarity between the peripheral motion vectors.

In step S537, the table selection unit 543 selects a table in accordance with the magnitude relationship between the similarity and the similarity threshold MV_th.

In steps S538 through S542, the same procedures as steps S338 through S342 are carried out.

After the procedure of step S542 is completed, the entropy encoding unit 337 ends the inter prediction mode information encoding operation. The operation then returns to step S324 of FIG. 17, and moves on to step S325.

As the respective operations are performed in the above described manner, the lossless encoding unit 306 can also reduce the bit rate of the predicted motion vector select information (pmv_index) in this case. In this manner, the image encoding device 300 can increase encoding efficiency.

[Lossless Decoding Unit and Assignment Control Unit]

Next, the image decoding device 400 compatible with the image encoding device 300 in this case is described.

FIG. 33 is a block diagram showing typical example structures of the lossless decoding unit 402 and the assignment control unit 421 of the image decoding device 400 in this case.

In this case, the lossless decoding unit 402 has the same structure as that in the case illustrated in FIG. 20, but the assignment control unit 421 includes a similarity calculation unit 641 and a table selection unit 642.

The entropy decoding unit 431 decodes the encoded data of the similarity threshold MV_th used in the image encoding device 300. The debinarization unit 432 debinarizes the obtained binarized data, and supplies the obtained similarity threshold MV_th to the table selection unit 642.

The similarity calculation unit 641 acquires peripheral motion vectors stored in the motion vector storage unit 437, and calculates the similarity between the peripheral motion vectors. The method of calculating the similarity is the same as the method used by the similarity calculation unit 542.

The similarity calculation unit 641 supplies the calculated similarity to the table selection unit 642.

The table selection unit 642 compares the similarity with the similarity threshold MV_th, and, in accordance with the magnitude relationship, selects a table (a bit sequence assignment pattern) Sn. The method of selecting a table is the same as the method used by the table selection unit 543.

The table selection unit 642 supplies the selection result Sn to the debinarization unit 434 of the lossless decoding unit 402.

As described above, as the assignment control unit 421 appropriately controls the bit sequence assignment in accordance with the similarity between peripheral motion vectors, the lossless decoding unit 402 can reproduce the same bit sequence assignment as that used in the encoding, and correctly decode the encoded data supplied from the image encoding device 300. In short, the image decoding device 400 can increase encoding efficiency.

[Flow of the Inter Prediction Mode Information Decoding Operation]

Referring now to the flowchart shown in FIG. 34, an example flow of the inter prediction mode information decoding operation in this case is described.

The operation to be performed in this case is also basically the same as the operation performed in the example case illustrated in FIG. 23.

In step S631, however, the entropy decoding unit 431 and the debinarization unit 432 extract the encoded data of the similarity threshold MV_th from the SPS, and decode and debinarize the extracted encoded data.

The similarity calculation unit 641 of the assignment control unit 421 acquires peripheral motion vectors from the motion vector storage unit 437 in step 632, and calculates the similarity between the acquired peripheral motion vectors in step S633.

In step S634, the table selection unit 642 selects a table in accordance with the magnitude relationship between the similarity and the similarity threshold MV_th.

In steps S635 through S642, the same procedures as steps S434 through S441 are carried out.

After the procedure of step S642 is completed, the debinarization unit 432 ends the inter prediction mode information decoding operation. The operation then returns to step S421 of FIG. 22, and moves on to step S422.

As described above, by performing the respective operations, the lossless decoding unit 402 can also reproduce the same bit sequence assignment as that used in the encoding, and correctly decode the encoded data supplied from the image encoding device 300 in this case. In short, the image decoding device 400 can increase encoding efficiency.

[Other Examples]

Like the distance threshold dPOC_th, the similarity threshold MV_th may be a fixed value that is determined in advance. Also, more than one similarity threshold MV_th may be prepared. Further, like the distance threshold dPOC_th, the similarity threshold MV_th can also be stored in any position in a stream, other than the SPS. Also, like the distance threshold dPOC_th, the similarity threshold MV_th can also be changed for each arbitrary processing unit.

<3. Third Embodiment>

[Lossless Encoding Unit and Assignment Control Unit]

In the above description, a parameter threshold such as the distance threshold or the similarity threshold is transmitted from the image encoding device 300 to the image decoding device 400, and the same table selection as that performed in the image encoding device 300 is performed in the image decoding device 400 using the threshold value. However, the present invention is not limited to them, and information indicating the table that has been selected in the image encoding device 300 may be provided to the image decoding device 400. In the image decoding device 400 in this case, the same table as the table that has been selected in the image encoding device 300 is selected based on the information.

In this case, the image decoding device 400 can select the same table as that selected in the image encoding device 300, without depending on the table selection method used in the image encoding device 300.

For example, the image encoding device 300 may control the bit sequence assignment pattern based on the cost function values of the results of predicted motion vector selection, as described below.

FIG. 35 is a block diagram showing typical example structures of the lossless encoding unit 306 and the assignment control unit 321 in such a case.

In this case, the lossless encoding unit 306 also has the same structure as that of the above described other embodiments, but the assignment control unit 321 calculates the cost function values of the results of the predicted motion vector selection performed by the lossless encoding unit 306, and controls the bit sequence assignment pattern based on the cost function values.

The assignment control unit **321** includes a cost function value calculation unit **741**, a cost function value storage unit **742**, and a table selection unit **743**.

The cost function value calculation unit **741** acquires the predicted motion vector select information from the predicted motion vector selection unit **332**, and calculates the cost function values of selection results for table (Sn) selection. The cost function value calculation unit **741** supplies the calculated cost function values for Sn to the cost function value storage unit **742**.

The cost function value storage unit **742** aggregates the supplied cost functions values for Sn in each table stored in the table storage unit **334**, and then stores the cost function values for Sn. The aggregation result is used in selecting tables for regions to be processed in later stages in terms of time than the current PU, which is the current object to be processed.

The table selection unit **743** acquires the result of aggregation of the cost function values for Sn in each of the tables stored in the cost function value storage unit **742**. Based on the aggregation result, the table selection unit **743** selects a table (Sn), and supplies the selection result to the binarization unit **335**.

The binarization unit **335** refers to the table information that is stored in the table storage unit **334** and has been selected by the table selection unit **743**, and binarizes the predicted motion vector select information. The binarized data is supplied to the entropy encoding unit **337**, and is then encoded.

The table selection unit **743** also supplies the selection result Sn to the binarization unit **336**. Specifically, the table selection result Sn from the table selection unit **743** is binarized by the binarization unit **336**, is encoded by the entropy encoding unit **337**, and is then supplied to the image decoding device **400**.

As described above, the assignment control unit **321** can appropriately control the bit sequence assignment in accordance with the cost function values of the results of predicted motion vector selection. That is, the assignment control unit **321** can also assign a bit sequence having a shorter code length to the selection information about a motion vector having a higher designation frequency in this case. In other words, the assignment control unit **321** can assign a bit sequence having a longer code length to the selection information about a motion vector having a lower designation frequency. Accordingly, the lossless encoding unit **306** can reduce the bit rate of the predicted motion vector select information (pmv_index). In this manner, the image encoding device **300** can increase encoding efficiency.

[Flow of the Inter Prediction Mode Information Encoding Operation]

Referring now to the flowchart shown in FIG. **36**, an example flow of the inter prediction mode information encoding operation in this case is described.

The operation to be performed in this case is also basically the same as the operation performed in the case where the distance threshold is used as described above with reference to the flowchart shown in FIG. **18**.

In steps S**731** through S**733**, the same procedures as steps S**333** through S**335** are carried out.

In step S**734**, the table selection unit **743** selects a table based on (the aggregation result in each table of) the cost function values of the past regions stored in the cost function value storage unit **742**.

In step S**735**, the binarization unit **336** and the entropy encoding unit **337** binarize and encode the table select information (the result of table selection) obtained in step S**734**, and stores the table select information into the SPS.

In steps S**736** through S**739**, the same procedures as steps S**338** through S**341** are carried out.

In step S**740**, the cost function value calculation unit **741** calculates the cost function values corresponding to each table with respect to the predicted motion vector select information. In step S**741**, the cost function value storage unit **742** aggregates and stores the cost function values calculated in step S**740** for each table.

In step S**742**, the same procedure as step S**342** is carried out. After the procedure of step S**742** is completed, the entropy encoding unit **337** ends the inter prediction mode information encoding operation. The operation then returns to step S**324** of FIG. **17**, and moves on to step S**325**.

As the respective operations are performed in the above described manner, the lossless encoding unit **306** can also reduce the bit rate of the predicted motion vector select information (pmv_index) in this case. In this manner, the image encoding device **300** can increase encoding efficiency.

[Lossless Decoding Unit and Assignment Control Unit]

Next, the image decoding device **400** compatible with the image encoding device **300** in this case is described.

FIG. **37** is a block diagram showing a typical example structure of the lossless decoding unit **402** of the image decoding device **400** in this case. In this case, the image decoding device **400** selects a table by using the table select information Sn supplied from the image encoding device **300**, and therefore, the assignment control unit **421** is removed.

As shown in FIG. **37**, unlike the lossless decoding unit **402** in the example case illustrated in FIG. **20**, the lossless decoding unit **402** in this case includes a debinarization unit **832** in place of the debinarization unit **432**, and a debinarization unit **834** in place of the debinarization unit **434**.

Like the debinarization unit **432**, the debinarization unit **832** debinarizes the binarized data of the coefficient data, the optimum mode information, the filter information, the difference motion vector, and the like, and also debinarizes the binarized data of the table select information Sn. The debinarization unit **832** supplies the table select information Sn obtained through the debinarization, to the debinarization unit **834**.

The debinarization unit **834** refers to the table information that is stored in the table storage unit **433** and is indicated by the table select information Sn supplied from the debinarization unit **832**, and debinarizes the binarized data that is formed by binarizing the predicted motion vector select information and is supplied from the entropy decoding unit **431**.

The debinarization unit **834** supplies the predicted motion vector select information obtained through the debinarization, to the predicted motion vector selection unit **435**.

In this manner, the lossless decoding unit **402** appropriately debinarizes the binarized data of the predicted motion vector select information, by using the result of table information selection performed in the image encoding device **300**, the result being supplied from the image encoding device **300**. That is, the lossless decoding unit **402** can also reproduce the same bit sequence assignment as that used in the encoding, and correctly decode the encoded data supplied from the image encoding device **300** in this case. In short, the image decoding device **400** can increase encoding efficiency.

[Flow of the Inter Prediction Mode Information Decoding Operation]

Referring now to the flowchart shown in FIG. **38**, an example flow of the inter prediction mode information decoding operation in this case is described.

The operation to be performed in this case is also basically the same as the operation performed in the example case illustrated in FIG. **23**.

In step S**831**, however, the entropy decoding unit **431** and the debinarization unit **832** extract the encoded data of the table select information Sn from the SPS, and decode and debinarize the extracted encoded data. That is, a table is selected at this point.

In steps S**832** through S**839**, the same procedures as steps S**434** through S**441** are carried out.

After the procedure of step S**839** is completed, the debinarization unit **832** ends the inter prediction mode information decoding operation. The operation then returns to step S**421** of FIG. **22**, and moves on to step S**422**.

As described above, by performing the respective operations, the lossless decoding unit **402** can also reproduce the same bit sequence assignment as that used in the encoding, and correctly decode the encoded data supplied from the image encoding device **300** in this case. In short, the image decoding device **400** can increase encoding efficiency.

[Other Examples]

In the above description, the cost function values are calculated based on the predicted motion vector select information about the regions that have been processed in the past, and the table information about the current region to be processed is selected by using the cost function values. However, the table information about the current region to be processed may be selected by using the cost function value of the predicted motion vector select information about the current region to be processed.

Although the table select information Sn is stored into the SPS in the above description, the table select information Sn may be stored in any position in a stream other than the SPS, like the distance threshold dPOC_th.

The method of transmitting the table select information Sn from the image encoding device **300** to the image decoding device **400** can be applied in the above described case where the image encoding device **300** selects a table by using the distance threshold dPOC_th, or in the above described case where the image encoding device **300** selects a table by using the similarity threshold MV_th. In either case, however, the image decoding device **400** selects a table based on the table select information Sn supplied from the image encoding device **300**, as described above with reference to FIG. **37**.

In any of the above described cases, the switching of tables can be performed for each arbitrary processing unit, such as each PU (or each divided part thereof), each slice, each picture, or each sequence.

<4. Fourth Embodiment>

[Personal Computer]

The above described series of operations can be performed by hardware or can be performed by software. In this case, the operations may be performed by the computer shown in FIG. **39**, for example.

In FIG. **39**, the CPU (Central Processing Unit) **901** of the personal computer **900** performs various kinds of operations in accordance with a program stored in a ROM (Read Only Memory) **902** or a program loaded into a RAM (Random Access Memory) **903** from a storage unit **913**. The data necessary for the CPU **901** to perform various kinds of operations is also stored in the RAM **903** where necessary.

The CPU **901**, the ROM **902**, and the RAM **903** are connected to one another via a bus **904**. An input/output interface **910** is also connected to the bus **904**.

The input/output interface **910** has the following components connected thereto: an input unit **911** formed with a keyboard, a mouse, or the like; an output unit **912** formed with a display such as a CRT (Cathode Ray Tube) or a LCD (Liquid Crystal Display), and a speaker; the storage unit **913** formed with a hard disk or the like; and a communication unit **914** formed with a modem. The communication unit **914** performs communications via networks including the Internet.

A drive **915** is also connected to the input/output interface **910** where necessary, and a removable medium **921** such as a magnetic disk, an optical disk, a magnetooptical disk, or a semiconductor memory is mounted on the drive as appropriate. A computer program read from such a removable disk is installed in the storage unit **913** where necessary.

When the above described series of operations are performed by software, a program to form the software is installed from a network or a recording medium.

As shown in FIG. **39**, this recording medium is formed with the removable medium **921** that is distributed for delivering the program to users separately from the device, such as a magnetic disk (including a flexible disk), an optical disk (including a CD-ROM (Compact Disc-Read Only Memory) or a DVD (Digital Versatile Disc)), a magnetooptical disk (including an MD (Mini Disc)), or a semiconductor memory, which has the program recorded thereon. Alternatively, the recording medium may be formed with the ROM **902** having the program recorded therein or a hard disk included in the storage unit **913**. Such a recording medium is incorporated beforehand into the device prior to the delivery to users.

The program to be executed by the computer may be a program for carrying out processes in chronological order in accordance with the sequence described in this specification, or a program for carrying out processes in parallel or whenever necessary such as in response to a call.

In this specification, the step written in the program to be recorded in a recording medium includes operations to be performed in parallel or independently of one another if not necessarily in chronological order, as well as operations to be performed in chronological order in accordance with the sequence described herein.

In this specification, a “system” means an entire apparatus formed with two or more devices (apparatuses).

Also, in the above described examples, any structure described as one device (or one processing unit) may be divided into two or more devices (or processing units). Conversely, any structure described as two or more devices (or processing units) may be combined to form one device (or one processing unit). Also, it is of course possible to add a structure other than the above described ones to the structure of any of the devices (or any of the processing units). Further, as long as the structure and function of the entire system remain the same, part of the structure of a device (or a processing unit) may be incorporated into another device (or another processing unit). That is, embodiments of the present technique are not limited to the above described embodiments, and various modifications may be made to them without departing from the scope of the technique.

For example, the above described image encoding device **300** and the image decoding device **400** can be applied to any electronic apparatuses. The following is a description of such examples.

<5. Fifth Embodiment>

[Television Receiver]

FIG. **40** is a block diagram showing a typical example structure of a television receiver using the image decoding device **400**.

The television receiver **1000** shown in FIG. **40** includes a terrestrial tuner **1013**, a video decoder **1015**, a video signal processing circuit **1018**, a graphic generation circuit **1019**, a panel drive circuit **1020**, and a display panel **1021**.

The terrestrial tuner **1013** receives a broadcast wave signal of analog terrestrial broadcasting via an antenna, and demodulates the signal to obtain a video signal. The terrestrial tuner **1013** supplies the video signal to the video decoder **1015**. The video decoder **1015** performs a decoding operation on the video signal supplied from the terrestrial tuner **1013**, and supplies the resultant digital component signal to the video signal processing circuit **1018**.

The video signal processing circuit **1018** performs predetermined processing such as denoising on the video data supplied from the video decoder **1015**, and supplies the resultant video data to the graphic generation circuit **1019**.

The graphic generation circuit **1019** generates video data of a show to be displayed on the display panel **1021**, or image data by performing an operation based on an application supplied via a network. The graphic generation circuit **1019** supplies the generated video data or image data to the panel drive circuit **1020**. The graphic generation circuit **1019** also generates video data (graphics) for displaying a screen to be used by a user to select an item, and superimposes the video data on the video data of the show. The resultant video data is supplied to the panel drive circuit **1020** where appropriate.

Based on the data supplied from the graphic generation circuit **1019**, the panel drive circuit **1020** drives the display panel **1021**, and causes the display panel **1021** to display the video image of the show and each screen described above.

The display panel **1021** is formed with an LCD (Liquid Crystal Display) or the like, and displays the video image of a show or the like under the control of the panel drive circuit **1020**.

The television receiver **1000** also includes an audio A/D (Analog/Digital) converter circuit **1014**, an audio signal processing circuit **1022**, an echo cancellation/voice synthesis circuit **1023**, an audio amplifier circuit **1024**, and a speaker **1025**.

The terrestrial tuner **1013** obtains not only a video signal but also an audio signal by demodulating a received broadcast wave signal. The terrestrial tuner **1013** supplies the obtained audio signal to the audio A/D converter circuit **1014**.

The audio A/D converter circuit **1014** performs an A/D converting operation on the audio signal supplied from the terrestrial tuner **1013**, and supplies the resultant digital audio signal to the audio signal processing circuit **1022**.

The audio signal processing circuit **1022** performs predetermined processing such as denoising on the audio data supplied from the audio A/D converter circuit **1014**, and supplies the resultant audio data to the echo cancellation/voice synthesis circuit **1023**.

The echo cancellation/voice synthesis circuit **1023** supplies the audio data supplied from the audio signal processing circuit **1022** to the audio amplifier circuit **1024**.

The audio amplifier circuit **1024** performs a D/A converting operation and an amplifying operation on the audio data supplied from the echo cancellation/voice synthesis circuit **1023**. After adjusted to a predetermined sound volume, the sound is output from the speaker **1025**.

The television receiver **1000** further includes a digital tuner **1016** and an MPEG decoder **1017**.

The digital tuner **1016** receives a broadcast wave signal of digital broadcasting (digital terrestrial broadcasting or digital BS (Broadcasting Satellite)/CS (Communications Satellite) broadcasting) via the antenna, and demodulates the broadcast wave signal, to obtain an MPEG-TS (Moving Picture Experts Group-Transport Stream). The MPEG-TS is supplied to the MPEG decoder **1017**.

The MPEG decoder **1017** descrambles the MPEG-TS supplied from the digital tuner **1016**, and extracts the stream containing the data of the show to be reproduced (to be viewed). The MPEG decoder **1017** decodes the audio packet forming the extracted stream, and supplies the resultant audio data to the audio signal processing circuit **1022**. The MPEG decoder **1017** also decodes the video packet forming the stream, and supplies the resultant video data to the video signal processing circuit **1018**. The MPEG decoder **1017** also supplies EPG (Electronic Program Guide) data extracted from the MPEG-TS to a CPU **1032** via a path (not shown).

The television receiver **1000** uses the above described image decoding device **400** as the MPEG decoder **1017**, which decodes the video packet as described above. The MPEG-TS transmitted from a broadcast station or the like has been encoded by the image encoding device **300**.

As in the case of the image decoding device **400**, the MPEG decoder **1017** appropriately controls bit sequence assignment in accordance with a predetermined parameter. Accordingly, the MPEG decoder **1017** can reproduce the same bit sequence assignment as that used in the encoding, and correctly decode encoded data supplied from the encoding side. In this manner, the MPEG decoder **1017** can increase encoding efficiency for encoded data.

The video data supplied from the MPEG decoder **1017** is subjected to predetermined processing at the video signal processing circuit **1018**, as in the case of the video data supplied from the video decoder **1015**. At the graphic generation circuit **1019**, generated video data and the like are superimposed on the video data where appropriate. The resultant video data is supplied to the display panel **1021** via the panel drive circuit **1020**, and the image is displayed.

The audio data supplied from the MPEG decoder **1017** is subjected to predetermined processing at the audio signal processing circuit **1022**, as in the case of the audio data supplied from the audio A/D converter circuit **1014**. The resultant audio data is supplied to the audio amplifier circuit **1024** via the echo cancellation/voice synthesis circuit **1023**, and is subjected to a D/A converting operation or an amplifying operation. As a result, a sound that is adjusted to a predetermined sound level is output from the speaker **1025**.

The television receiver **1000** also includes a microphone **1026** and an A/D converter circuit **1027**.

The A/D converter circuit **1027** receives a signal of a user's voice captured by the microphone **1026** provided for voice conversations in the television receiver **1000**. The A/D converter circuit **1027** performs an A/D converting operation on the received audio signal, and supplies the resultant digital audio data to the echo cancellation/voice synthesis circuit **1023**.

When audio data of a user (a user A) of the television receiver **1000** is supplied from the A/D converter circuit **1027**, the echo cancellation/voice synthesis circuit **1023** performs echo cancellation on the audio data of the user A, and combines the audio data with other audio data or the like. The resultant audio data is output from the speaker **1025** via the audio amplifier circuit **1024**.

The television receiver **1000** further includes an audio codec **1028**, an internal bus **1029**, an SDRAM (Synchronous Dynamic Random Access Memory) **1030**, a flash memory **1031**, the CPU **1032**, a USB (Universal Serial Bus) I/F **1033**, and a network I/F **1034**.

The A/D converter circuit **1027** receives the signal of the user's voice captured by the microphone **1026** provided for voice conversations in the television receiver **1000**. The A/D converter circuit **1027** performs an A/D converting operation on the received audio signal, and supplies the resultant digital audio data to the audio codec **1028**.

The audio codec **1028** transforms the audio data supplied from the A/D converter circuit **1027** into data in a predetermined format for transmission via a network, and supplies the result to the network I/F **1034** via the internal bus **1029**.

The network I/F **1034** is connected to a network via a cable attached to a network terminal **1035**. The network I/F **1034** transmits the audio data supplied from the audio codec **1028** to another device connected to the network, for example. The network I/F **1034** also receives, via the network terminal **1035**, audio data transmitted from another device connected to the network, and supplies the audio data to the audio codec **1028** via the internal bus **1029**.

The audio codec **1028** transforms the audio data supplied from the network I/F **1034** into data in a predetermined format, and supplies the result to the echo cancellation/voice synthesis circuit **1023**.

The echo cancellation/voice synthesis circuit **1023** performs echo cancellation on the audio data supplied from the audio codec **1028**, and combines the audio data with other audio data or the like. The resultant audio data is output from the speaker **1025** via the audio amplifier circuit **1024**.

The SDRAM **1030** stores various kinds of data necessary for the CPU **1032** to perform processing.

The flash memory **1031** stores the program to be executed by the CPU **1032**. The program stored in the flash memory **1031** is read by the CPU **1032** at a predetermined time, such as when the television receiver **1000** is activated. The flash memory **1031** also stores EPG data obtained through digital broadcasting, data obtained from a predetermined server via a network, and the like.

For example, the flash memory **1031** stores a MPEG-TS containing content data obtained from a predetermined server via a network, under the control of the CPU **1032**. The flash memory **1031** supplies the MPEG-TS to the MPEG decoder **1017** via the internal bus **1029**, under the control of the CPU **1032**, for example.

The MPEG decoder **1017** processes the MPEG-TS, as in the case of the MPEG-TS supplied from the digital tuner **1016**. In this manner, the television receiver **1000** receives the content data formed with a video image and a sound via the network, and decodes the content data by using the MPEG decoder **1017**, to display the video image and output the sound.

The television receiver **1000** also includes a light receiving unit **1037** that receives an infrared signal transmitted from a remote controller **1051**.

The light receiving unit **1037** receives an infrared ray from the remote controller **1051**, and performs demodulation. The light receiving unit **1037** outputs a control code indicating the contents of a user operation obtained through the demodulation, to the CPU **1032**.

The CPU **1032** executes the program stored in the flash memory **1031**, and controls the entire operation of the television receiver **1000** in accordance with the control code and the like supplied from the light receiving unit **1037**. The respective components of the television receiver **1000** are connected to the CPU **1032** via paths (not shown).

The USB I/F **1033** exchanges data with an apparatus that is located outside the television receiver **1000** and is connected thereto via a USB cable attached to a USB terminal **1036**. The network I/F **1034** is connected to the network via the cable attached to the network terminal **1035**, and also exchanges data other than audio data with various kinds of devices connected to the network.

Using the image decoding device **400** as the MPEG decoder **1017**, the television receiver **1000** can increase the encoding efficiency of broadcast wave signals received via an antenna or content data obtained via a network.

<6. Sixth Embodiment>

[Portable Telephone Device]

FIG. **41** is a block diagram showing a typical example structure of a portable telephone device using the image encoding device **300** and the image decoding device **400**.

The portable telephone device **1100** shown in FIG. **41** includes a main control unit **1150** designed to collectively control respective components, a power source circuit unit **1151**, an operation input control unit **1152**, an image encoder **1153**, a camera I/F unit **1154**, an LCD control unit **1155**, an image decoder **1156**, a multiplexing/separating unit **1157**, a recording/reproducing unit **1162**, a modulation/demodulation circuit unit **1158**, and an audio codec **1159**. Those components are connected to one another via a bus **1160**.

The portable telephone device **1100** also includes operation keys **1119**, a CCD (Charge Coupled Device) camera **1116**, a liquid crystal display **1118**, a storage unit **1123**, a transmission/reception circuit unit **1163**, an antenna **1114**, a microphone (mike) **1121**, and a speaker **1117**.

When a call is ended or the power key is switched on by a user's operation, the power source circuit unit **1151** puts the portable telephone device **1100** into an operable state by supplying power from a battery pack to the respective components.

Under the control of the main control unit **1150** formed with a CPU, a ROM, a RAM, and the like, the portable telephone device **1100** performs various kinds of operations, such as transmission and reception of audio signals, transmission and reception of electronic mail and image data, image capturing, and data recording, in various kinds of modes such as a voice communication mode and a data communication mode.

In the portable telephone device **1100** in the voice communication mode, for example, an audio signal captured by the microphone (mike) **1121** is transformed into digital audio data by the audio codec **1159**, and the digital audio data is subjected to spread spectrum processing at the modulation/demodulation circuit unit **1158**. The resultant data is then subjected to a digital-analog converting operation and a frequency converting operation at the transmission/reception circuit unit **1163**. The portable telephone device **1100** transmits the transmission signal obtained through the converting operations to a base station (not shown) via the antenna **1114**. The transmission signal (audio signal) transmitted to the base station is further supplied to the portable telephone device at the other end of the communication via a public telephone line network.

Also, in the portable telephone device **1100** in the voice communication mode, for example, a reception signal received by the antenna **1114** is amplified at the transmission/reception circuit unit **1163**, and is further subjected to a frequency converting operation and an analog-digital converting operation. The resultant signal is subjected to inverse spread spectrum processing at the modulation/demodulation circuit unit **1158**, and is transformed into an analog audio signal by the audio codec **1159**. The portable telephone device **1100** outputs, from the speaker **1117**, the analog audio signal obtained through the conversions.

Further, when electronic mail is transmitted in the data communication mode, for example, the operation input control unit **1152** of the portable telephone device **1100** receives text data of the electronic mail that is input by operating the operation keys **1119**. The portable telephone device **1100** processes the text data at the main control unit **1150**, and displays the text data as an image on the liquid crystal display **1118** via the LCD control unit **1155**.

In the portable telephone device **1100**, the main control unit **1150** generates electronic mail data based on text data, a user's instruction, or the like received by the operation input control unit **1152**. The portable telephone device **1100** subjects the electronic mail data to spread spectrum processing at the modulation/demodulation circuit unit **1158**, and to a digital-analog converting operation and a frequency converting operation at the transmission/reception circuit unit **1163**. The portable telephone device **1100** transmits the transmission signal obtained through the converting operations to a base station (not shown) via the antenna **1114**. The transmission signal (electronic mail) transmitted to the base station is supplied to a predetermined address via a network, a mail server, and the like.

When electronic mail is received in the data communication mode, for example, the transmission/reception circuit unit **1163** of the portable telephone device **1100** receives a signal transmitted from a base station via the antenna **1114**, and the signal is amplified and is further subjected to a frequency converting operation and an analog-digital converting operation. The portable telephone device **1100** subjects the received signal to inverse spread spectrum processing at the modulation/demodulation circuit unit **1158**, to restore the original electronic mail data. The portable telephone device **1100** displays the restored electronic mail data on the liquid crystal display **1118** via the LCD control unit **1155**.

The portable telephone device **1100** can also record (store) the received electronic mail data into the storage unit **1123** via the recording/reproducing unit **1162**.

The storage unit **1123** is a rewritable storage medium. The storage unit **1123** may be a semiconductor memory such as a RAM or an internal flash memory, a hard disk, or a removable medium such as a magnetic disk, a magnetooptical disk, an optical disk, a USB memory, or a memory card. It is of course possible to use a memory other than the above.

Further, when image data is transmitted in the data communication mode, for example, the portable telephone device **1100** generates the image data at the CCD camera **1116** capturing an image. The CCD camera **1116** includes optical devices such as a lens and a diaphragm, and a CCD as a photoelectric conversion device. The CCD camera **1116** captures an image of an object, converts the intensity of received light into an electrical signal, and generates image data of the image of the object. The CCD camera **1116** encodes the image data at the image encoder **1153** via the camera I/F unit **1154**, to obtain encoded image data.

The portable telephone device **1100** uses the above described image encoding device **300** as the image encoder **1153** that performs the above operation. As in the case of the image encoding device **300**, the image encoder **1153** appropriately controls bit sequence assignment in accordance with a predetermined parameter. That is, the image encoder **1153** can assign a bit sequence having a shorter code length to the selection information about a motion vector having a higher designation frequency. In this manner, the image encoder **1153** can increase encoding efficiency for encoded data.

At the same time as above, in the portable telephone device **1100**, the sound captured by the microphone (mike) **1121** during the image capturing by the CCD camera **1116** is analog-digital converted at the audio codec **1159**, and is further encoded.

The multiplexing/separating unit **1157** of the portable telephone device **1100** multiplexes the encoded image data supplied from the image encoder **1153** and the digital audio data supplied from the audio codec **1159** by a predetermined method. The portable telephone device **1100** subjects the resultant multiplexed data to spread spectrum processing at the modulation/demodulation circuit unit **1158**, and to a digital-analog converting operation and a frequency converting operation at the transmission/reception circuit unit **1163**. The portable telephone device **1100** transmits the transmission signal obtained through the converting operations to a base station (not shown) via the antenna **1114**. The transmission signal (image data) transmitted to the base station is supplied to the other end of the communication via a network or the like.

When image data is not transmitted, the portable telephone device **1100** can also display image data generated at the CCD camera **1116** on the liquid crystal display **1118** via the LCD control unit **1155**, instead of the image encoder **1153**.

When the data of a moving image file linked to a simplified homepage or the like is received in the data communication mode, for example, the transmission/reception circuit unit **1163** of the portable telephone device **1100** receives a signal transmitted from a base station via the antenna **1114**. The signal is amplified, and is further subjected to a frequency converting operation and an analog-digital converting operation. The portable telephone device **1100** subjects the received signal to inverse spread spectrum processing at the modulation/demodulation circuit unit **1158**, to restore the original multiplexed data. The portable telephone device **1100** divides the multiplexed data into encoded image data and audio data at the multiplexing/separating unit **1157**.

By decoding the encoded image data at the image decoder **1156**, the portable telephone device **1100** generates reproduced moving image data, and displays the reproduced moving image data on the liquid crystal display **1118** via the LCD control unit **1155**. In this manner, the moving image data contained in a moving image file linked to a simplified homepage, for example, is displayed on the liquid crystal display **1118**.

The portable telephone device **1100** uses the above described image decoding device **400** as the image decoder **1156** that performs the above operation. As in the case of the image decoding device **400**, the image decoder **1156** appropriately controls bit sequence assignment in accordance with a predetermined parameter. Accordingly, the image decoder **1156** can reproduce the same bit sequence assignment as that used in the encoding, and correctly decode encoded data supplied from the encoding side. In this manner, the image decoder **1156** can increase encoding efficiency for encoded data.

At the same time as above, the portable telephone device **1100** transforms the digital audio data into an analog audio signal at the audio codec **1159**, and outputs the analog audio signal from the speaker **1117**. In this manner, the audio data contained in a moving image file linked to a simplified homepage, for example, is reproduced.

As in the case of electronic mail, the portable telephone device **1100** can also record (store) received data linked to a simplified homepage or the like into the storage unit **1123** via the recording/reproducing unit **1162**.

The main control unit **1150** of the portable telephone device **1100** can also analyze a two-dimensional code obtained by the CCD camera **1116** performing image capturing, and obtain the information recorded in the two-dimensional code.

Further, an infrared communication unit **1181** of the portable telephone device **1100** can communicate with an external apparatus by using infrared rays.

By using the image encoding device **300** as the image encoder **1153**, the portable telephone device **1100** can increase encoding efficiency for encoded data when image data generated by the CCD camera **1116** is encoded and is then transmitted, for example.

Also, by using the image decoding device **400** as the image decoder **1156**, the portable telephone device **1100** can increase the encoding efficiency for the data (encoded data) of a moving image file linked to a simplified homepage, for example.

In the above description, the portable telephone device **1100** uses the CCD camera **1116**. However, instead of the CCD camera **1116**, an image sensor (a CMOS image sensor) using a CMOS (Complementary Metal Oxide Semiconductor) may be used. In that case, the portable telephone device **1100** can also capture an image of an object, and generate the image data of the image of the object, as in the case where the CCD camera **1116** is used.

Although the portable telephone device **1100** has been described above, the image encoding device **300** and the image decoding device **400** can also be applied to any device in the same manner as in the case of the portable telephone device **1100**, as long as the device has the same image capturing function and the same communication function as the portable telephone **1100**. Such a device may be a PDA (Personal Digital Assistant), a smartphone, an UMPC (Ultra Mobile Personal Computer), a netbook, or a notebook personal computer, for example.

<7. Seventh Embodiment>

[Hard Disk Recorder]

FIG. **42** is a block diagram showing a typical example structure of a hard disk recorder using the image encoding device **300** and the image decoding device **400**.

The hard disk recorder (a HDD recorder) **1200** shown in FIG. **42** is a device that stores, into an internal hard disk, the audio data and the video data of a broadcast show contained in a broadcast wave signal (a television signal) that is transmitted from a satellite or a terrestrial antenna or the like and is received by a tuner, and provides the stored data to a user at a time designated by an instruction from the user.

The hard disk recorder **1200** can extract audio data and video data from a broadcast wave signal, for example, decode those data where appropriate, and store the data into an internal hard disk. Also, the hard disk recorder **1200** can obtain audio data and video data from another device via a network, for example, decode those data where appropriate, and store the data into an internal hard disk.

Further, the hard disk recorder **1200** can decode audio data and video data recorded on an internal hard disk, for example, supply those data to a monitor **1260**, display the image on the screen of the monitor **1260**, and output the sound from the speaker of the monitor **1260**. Also, the hard disk recorder **1200** can decode audio data and video data extracted from a broadcast wave signal obtained via a tuner, or audio data and video data obtained from another device via a network, for example, supply those data to the monitor **1260**, display the image on the screen of the monitor **1260**, and output the sound from the speaker of the monitor **1260**.

The hard disk recorder **700** can of course perform operations other than the above.

As shown in FIG. **42**, the hard disk recorder **1200** includes a reception unit **1221**, a demodulation unit **1222**, a demultiplexer **1223**, an audio decoder **1224**, a video decoder **1225**, and a recorder control unit **1226**. The hard disk recorder **1200** further includes an EPG data memory **1227**, a program memory **1228**, a work memory **1229**, a display converter **1230**, an OSD (On-Screen Display) control unit **1231**, a display control unit **1232**, a recording/reproducing unit **1233**, a D/A converter **1234**, and a communication unit **1235**.

The display converter **1230** includes a video encoder **1241**. The recording/reproducing unit **1233** includes an encoder **1251** and a decoder **1252**.

The reception unit **1221** receives an infrared signal from a remote controller (not shown), converts the infrared signal into an electrical signal, and outputs the electrical signal to the recorder control unit **1226**. The recorder control unit **1226** is formed with a microprocessor, for example, and performs various kinds of operations in accordance with a program stored in the program memory **1228**. At this point, the recorder control unit **1226** uses the work memory **1229** where necessary.

The communication unit **1235** is connected to a network, and performs a communication operation with another device via the network. For example, under the control of the recorder control unit **1226**, the communication unit **1235** communicates with a tuner (not shown), and outputs a station select control signal mainly to the tuner.

The demodulation unit **1222** demodulates a signal supplied from the tuner, and outputs the signal to the demultiplexer **1223**. The demultiplexer **1223** divides the data supplied from the demodulation unit **1222** into audio data, video data, and EPG data. The demultiplexer **1223** outputs the audio data, the video data, and the EPG data to the audio decoder **1224**, the video decoder **1225**, and the recorder control unit **1226**, respectively.

The audio decoder **1224** decodes the input audio data, and outputs the decoded audio data to the recording/reproducing unit **1233**. The video decoder **1225** decodes the input video data, and outputs the decoded video data to the display converter **1230**. The recorder control unit **1226** supplies and stores the input EPG data into the EPG data memory **1227**.

The display converter **1230** encodes video data supplied from the video decoder **1225** or the recorder control unit **1226** into video data compliant with the NTSC (National Television Standards Committee) standards, for example, using the video encoder **1241**. The encoded video data is output to the recording/reproducing unit **1233**. Also, the display converter **1230** converts the screen size of video data supplied from the video decoder **1225** or the recorder control unit **1226** into a size compatible with the size of the monitor **1260**. The video encoder **1241** converts the video data into video data compliant with the NTSC standards. The NTSC video data is converted into an analog signal, and is output to the display control unit **1232**.

Under the control of the recorder control unit **1226**, the display control unit **1232** superimposes an OSD signal output from the OSD (On-Screen Display) control unit **1231** on the video signal input from the display converter **1230**, and outputs the resultant signal to the display of the monitor **1260** to display the image.

Audio data that is output from the audio decoder **1224** and is converted into an analog signal by the D/A converter **1234** is also supplied to the monitor **1260**. The monitor **1260** outputs the audio signal from an internal speaker.

The recording/reproducing unit **1233** includes a hard disk as a storage medium for recording video data, audio data, and the like.

The recording/reproducing unit **1233** causes the encoder **1251** to encode audio data supplied from the audio decoder **1224**, for example. The recording/reproducing unit **1233** also causes the encoder **1251** to encode video data supplied from the video encoder **1241** of the display converter **1230**. The recording/reproducing unit **1233** combines the encoded data of the audio data with the encoded data of the video data, using a multiplexer. The recording/reproducing unit **1233** amplifies the combined data through channel coding, and writes the resultant data on the hard disk via a recording head.

The recording/reproducing unit **1233** reproduces data recorded on the hard disk via a reproduction head, amplifies the data, and divides the data into audio data and video data by using a demultiplexer. The recording/reproducing unit **1233** decodes the audio data and the video data by using the decoder **1252**. The recording/reproducing unit **1233** performs a D/A conversion on the decoded audio data, and outputs the resultant data to the speaker of the monitor **1260**. The recording/reproducing unit **1233** also performs a D/A conversion on the decoded video data, and outputs the resultant data to the display of the monitor **1260**.

Based on a user's instruction indicated by an infrared signal that is transmitted from a remote controller and is received via the reception unit **1221**, the recorder control unit **1226** reads the latest EPG data from the EPG data memory **1227**, and supplies the EPG data to the OSD control unit **1231**. The OSD control unit **1231** generates image data corresponding to the input EPG data, and outputs the image data to the display control unit **1232**. The display control unit **1232** outputs the video data input from the OSD control unit **1231** to the display of the monitor **1260**, to display the image. In this manner, an EPG (Electronic Program Guide) is displayed on the display of the monitor **1260**.

The hard disk recorder **1200** can also obtain various kinds of data, such as video data, audio data, and EPG data, which are supplied from another device via a network such as the Internet.

Under the control of the recorder control unit **1226**, the communication unit **1235** obtains encoded data of video data, audio data, EPG data, and the like from another device via a network, and supplies those data to the recorder control unit **1226**. For example, the recorder control unit **1226** supplies encoded data of obtained video data and audio data to the recording/reproducing unit **1233**, and stores those data into the hard disk. At this point, the recorder control unit **1226** and the recording/reproducing unit **1233** may perform an operation such as a re-encoding where necessary.

The recorder control unit **1226** also decodes encoded data of obtained video data and audio data, and supplies the resultant video data to the display converter **1230**. The display converter **1230** processes the video data supplied from the recorder control unit **1226** in the same manner as processing video data supplied from the video decoder **1225**, and supplies the resultant data to the monitor **1260** via the display control unit **1232**, to display the image.

In synchronization with the image display, the recorder control unit **1226** may supply the decoded audio data to the monitor **1260** via the D/A converter **1234**, and output the sound from the speaker.

Further, the recorder control unit **1226** decodes encoded data of obtained EPG data, and supplies the decoded EPG data to the EPG data memory **1227**.

The above described hard disk recorder **1200** uses the image decoding device **400** as the video decoder **1225**, the decoder **1252**, and the decoder installed in the recorder control unit **1226**. As in the case of the image decoding device **400**, the video decoder **1225**, the decoder **1252**, and the decoder installed in the recorder control unit **1226** appropriately control bit sequence assignment in accordance with a predetermined parameter. Accordingly, the video decoder **1225**, the decoder **1252**, and the decoder installed in the recorder control unit **1226** can reproduce the same bit sequence assignment as that used in the encoding. In this manner, the video decoder **1225**, the decoder **1252**, and the decoder installed in the recorder control unit **1226** can increase encoding efficiency for encoded data.

Thus, the hard disk recorder **1200** can increase encoding efficiency for video data (encoded data) received by a tuner or the communication unit **1235** and video data (encoded data) to be reproduced by the recording/reproducing unit **1233**.

The hard disk recorder **1200** also uses the image encoding device **300** as the encoder **1251**. As in the case of the image encoding device **300**, the encoder **1251** appropriately controls bit sequence assignment in accordance with a predetermined parameter. That is, the encoder **1251** can assign a bit sequence having a shorter code length to the selection information about a motion vector having a higher designation frequency. In this manner, the encoder **1251** can increase encoding efficiency for encoded data.

Thus, the hard disk recorder **1200** can increase encoding efficiency for data to be recorded on the hard disk, for example.

In the above description, the hard disk recorder **1200** that records video data and audio data on a hard disk has been described. However, any other recording medium may be used. For example, as in the case of the above described hard disk recorder **1200**, the image encoding device **300** and the image decoding device **400** can be applied to a recorder that uses a recording medium other than a hard disk, such as a flash memory, an optical disk, or a videotape.

>8. Eighth Embodiment>

[Camera]

FIG. **43** is a block diagram showing a typical example structure of a camera using the image encoding device **300** and the image decoding device **400**.

The camera **1300** shown in FIG. **43** captures an image of an object, and displays the image of the object on an LCD **1316** or records the image of the object as image data on a recording medium **1333**.

A lens block **1311** has light (or a video image of an object) incident on a CCD/CMOS **1312**. The CCD/CMOS **1312** is an image sensor using a CCD or a CMOS. The CCD/CMOS **1312** converts the intensity of the received light into an electrical signal, and supplies the electrical signal to a camera signal processing unit **1313**.

The camera signal processing unit **1313** transforms the electrical signal supplied from the CCD/CMOS **1312** into a Y, Cr, Cb chrominance signal, and supplies the signal to an image signal processing unit **1314**. Under the control of a controller **1321**, the image signal processing unit **1314** performs predetermined image processing on the image signal supplied from the camera signal processing unit **1313**, and encodes the image signal by using an encoder **1341**. The image signal processing unit **1314** supplies the encoded data generated by encoding the image signal to a decoder **1315**. The image signal processing unit **1314** further obtains display data generated at an on-screen display (OSD) **1320**, and supplies the display data to the decoder **1315**.

In the above operation, the camera signal processing unit **1313** uses a DRAM (Dynamic Random Access Memory) **1318** connected thereto via a bus **1317**, to store the image data and the encoded data or the like generated by encoding the image data into the DRAM **1318** where necessary.

The decoder **1315** decodes the encoded data supplied from the image signal processing unit **1314**, and supplies the resultant image data (decoded image data) to the LCD **1316**. The decoder **1315** also supplies the display data supplied from the image signal processing unit **1314** to the LCD **1316**. The LCD **1316** combines the image corresponding to the decoded image data supplied from the decoder **1315** with the image corresponding to the display data, and displays the combined image.

Under the control of the controller **1321**, the on-screen display **1320** outputs the display data of a menu screen or icons formed with symbols, characters, and figures, to the image signal processing unit **1314** via the bus **1317**.

Based on a signal indicating contents designated by a user using an operation unit **1322**, the controller **1321** performs various kinds of operations, and controls, via the bus **1317**, the image signal processing unit **1314**, the DRAM **1318**, an external interface **1319**, the on-screen display **1320**, a media drive **1323**, and the like. A flash ROM **1324** stores programs, data, and the like necessary for the controller **1321** to perform various kinds of operations.

For example, in place of the image signal processing unit **1314** and the decoder **1315**, the controller **1321** can encode the image data stored in the DRAM **1318**, and decode the encoded data stored in the DRAM **1318**. In doing so, the controller **1321** may perform encoding and decoding operations by using the same methods as the encoding and decoding methods used by the image signal processing unit **1314** and the decoder **1315**, or may perform encoding and decoding operations by using methods that are not compatible with the image signal processing unit **1314** and the decoder **1315**.

When a start of image printing is requested through the operation unit **1322**, for example, the controller **1321** reads image data from the DRAM **1318**, and supplies the image data to a printer **1334** connected to the external interface **1319** via the bus **1317**, so that the printing is performed.

Further, when image recording is requested through the operation unit **1322**, for example, the controller **1321** reads encoded data from the DRAM **1318**, and supplies and stores the encoded data into the recording medium **1333** mounted on the media drive **1323** via the bus **1317**.

The recording medium **1333** is a readable and writable removable medium, such as a magnetic disk, a magnetooptical disk, an optical disk, or a semiconductor memory. The recording medium **1333** may be any kind of removable medium, and may be a tape device, a disk, or a memory card. It is of course possible to use a non-contact IC card or the like.

Alternatively, the media drive **1323** and the recording medium **1333** may be integrated, and may be formed with an immobile storage medium such as an internal hard disk drive or a SSD (Solid State Drive).

The external interface **1319** is formed with a USB input/output terminal and the like, for example, and is connected to the printer **1334** when image printing is performed. Also, a drive **1331** is connected to the external interface **1319** where necessary, and a removable medium **1332** such as a magnetic disk, an optical disk, or a magnetooptical disk is mounted on the drive **1331** where appropriate. A computer program that is read from such a disk is installed in the flash ROM **1324** where necessary.

Further, the external interface **1319** includes a network interface connected to a predetermined network such as a LAN or the Internet. In accordance with an instruction from the operation unit **1322**, for example, the controller **1321** can read encoded data from the DRAM **1318**, and supply the encoded data from the external interface **1319** to another device connected thereto via a network. Also, the controller **1321** can obtain encoded data and image data supplied from another device via a network, and store the data into the DRAM **1318** or supply the data to the image signal processing unit **1314** via the external interface **1319**.

The above camera **1300** uses the image decoding device **400** as the decoder **1315**. As in the case of the image decoding device **400**, the decoder **1315** appropriately controls bit sequence assignment in accordance with a predetermined parameter. Accordingly, the decoder **1315** can reproduce the same bit sequence assignment as that used in the encoding, and correctly decode encoded data supplied from the encoding side. In this manner, the decoder **1315** can increase encoding efficiency for encoded data.

Thus, the camera **1300** can increase encoding efficiency for image data generated at the CCD/CMOS **1312**, encoded data of video data read from the DRAM **1318** or the recording medium **1333**, or encoded data of video data obtained via a network, for example.

Also, the camera **1300** uses the image encoding device **300** as the encoder **1341**. As in the case of the image encoding device **300**, the encoder **1341** appropriately controls bit sequence assignment in accordance with a predetermined parameter. That is, the encoder **1341** can assign a bit sequence having a shorter code length to the selection information about a motion vector having a higher designation frequency. In this manner, the encoder **1341** can increase encoding efficiency for encoded data.

Thus, the camera **1300** can increase the encoding efficiency for encoded data to be recorded in the DRAM **1318** or the recording medium **1333**, and for encoded data to be provided to other devices, for example.

The decoding method used by the image decoding device **400** may be applied to decoding operations to be performed by the controller **1321**. Likewise, the encoding method used by the image encoding device **300** may be applied to encoding operations to be performed by the controller **1321**.

Image data to be captured by the camera **1300** may be of a moving image, or may be of a still image.

It is of course possible to use an image encoding device and an image decoding device having the present technique applied thereto in any devices and systems other than the above described devices.

The present technique can be applied to image encoding devices and image decoding devices that are used when image information (bit streams) compressed through orthogonal transforms such as discrete cosine transforms and motion compensation is received via a network medium such as satellite broadcasting, cable television, the Internet, or a portable telephone, or when such image information is processed in a storage medium such as an optical or magnetic disk or a flash memory, as in MPEG, H.26x, for example.

The present technique can also be in the following forms.

(1) An image processing device including:

an assignment control unit that controls assignment of a binary bit sequence to predicted motion vector select information indicating a motion vector selected as a predicted motion vector, to assign a bit sequence having a shorter code length to the select information about a motion vector having a higher designation frequency; and

a binarization unit that binarizes the predicted motion vector select information with the bit sequence assigned by the assignment control unit.

(2) The image processing device of (1), wherein

the assignment control unit includes a table selection unit that selects a table that designates the bit sequence to be assigned to the predicted motion vector select information in accordance with the type of the motion vector selected as the predicted motion vector, and

the binarization unit binarizes the predicted motion vector select information by using the table selected by the table selection unit.

(3) The image processing device of (2), wherein

the assignment control unit further includes a distance calculation unit that calculates the distance between the current picture and an anchor picture, and

the table selection unit selects the table based on the distance calculated by the distance calculation unit.

(4) The image processing device of (3), wherein

the assignment control unit further includes a distance threshold acquirement unit that acquires a distance threshold indicating the threshold of the distance, and

the table selection unit selects the table in accordance with the magnitude relationship between the distance calculated by the distance calculation unit and the distance threshold acquired by the distance threshold acquirement unit.

(5) The image processing device of (4), wherein the distance threshold acquired by the distance threshold acquirement unit is supplied to another device that decodes encoded data of the predicted motion vector select information.

(6) The image processing device of any of (2) to (5), wherein

the assignment control unit further includes a similarity calculation unit that calculates the similarity between peripheral predicted motion vectors, and

the table selection unit selects the table based on the similarity calculated by the similarity calculation unit.

(7) The image processing device of (6), wherein

the assignment control unit further includes a similarity threshold acquirement unit that acquires a similarity threshold indicating the threshold of the similarity, and

the table selection unit selects the table in accordance with the magnitude relationship between the similarity calculated by the similarity calculation unit and the similarity threshold acquired by the similarity threshold acquirement unit.

(8) The image processing device of (7), wherein the similarity threshold acquired by the similarity threshold acquirement unit is supplied to another device that decodes encoded data of the predicted motion vector select information.

(9) The image processing device of any of (2) to (8), wherein

the assignment control unit further includes a cost function value calculation unit that calculates a cost function value of the predicted motion vector select information, and

the table selection unit selects the table based on the cost function value calculated by the cost function value calculation unit.

(10) The image processing device of any of (2) to (9), wherein information indicating the result of the table selection performed by the table selection unit is supplied to another device that decodes encoded data of the predicted motion vector select information.

(11) The image processing device of any of (1) to (10), further including

an encoding unit that encodes the binarized data obtained through the binarization performed by the binarization unit.

(12) An image processing method for an image processing device, including:

controlling assignment of a binary bit sequence to predicted motion vector select information indicating a motion vector selected as a predicted motion vector, to assign a bit sequence having a shorter code length to the select information about a motion vector having a higher designation frequency, the controlling being performed by an assignment control unit; and

binarizing the predicted motion vector select information with the assigned bit sequence, the binarizing being performed by a binarization unit.

(13) An image processing device including:

a decoding unit that decodes encoded data of predicted motion vector select information indicating a motion vector selected as a predicted motion vector; and

a debinarization unit that debinarizes the binarized data of the predicted motion vector select information obtained through the decoding performed by the decoding unit, with a bit sequence that is assigned in an assigning operation controlled to assign a bit sequence having a shorter code length to the select information about a motion vector having a higher designation frequency.

(14) The image processing device of (13), further including

an assignment control unit that controls the bit sequence to be assigned to the predicted motion vector select information based on a parameter supplied from another device that has encoded the predicted motion vector select information,

wherein the debinarization unit debinarizes the predicted motion vector select information under the control of the assignment control unit.

(15) The image processing device of (14), wherein the assignment control unit includes a table selection unit that selects a table that designates the bit sequence to be assigned to the predicted motion vector select information in accordance with the type of the motion vector selected as the predicted motion vector.

(16) The image processing device of (15), wherein

the assignment control unit further includes a distance calculation unit that calculates the distance between the current picture and an anchor picture, and

the table selection unit selects the table in accordance with the magnitude relationship between the distance calculated by the distance calculation unit and a distance threshold supplied from the other device that has encoded the predicted motion vector select information.

(17) The image processing device of (15) or (16), wherein

the assignment control unit further includes a similarity calculation unit that calculates the similarity between peripheral predicted motion vectors, and

the table selection unit selects the table in accordance with the magnitude relationship between the similarity calculated by the similarity calculation unit and a similarity threshold supplied from the other device that has encoded the predicted motion vector select information.

(18) The image processing device of any of (13) to (17), wherein the debinarization unit debinarizes the binarized data of the predicted motion vector select information based on information indicating a table selection result supplied from the other device that has encoded the predicted motion vector select information.

(19) An image processing method for an image processing device, including:

decoding encoded data of predicted motion vector select information indicating a motion vector selected as a predicted motion vector, the decoding being performed by a decoding unit; and

debinarizing the binarized data of the predicted motion vector select information obtained through the decoding, with a bit sequence that is assigned in an assigning operation controlled to assign a bit sequence having a shorter code length to the select information about a motion vector having a higher designation frequency, the debinarizing being performed by a debinarization unit.

REFERENCE SIGNS LIST

300 Image encoding device, **306** Lossless encoding unit, **321** Assignment control unit, **331** Motion vector storage unit,

332 Predicted motion vector selection unit, **333** Difference motion vector calculation unit, **334** Table storage unit, **335** Binarization unit, **336** Binarization unit, **337** Entropy encoding unit, **341** Distance threshold acquirement unit, **342** Distance calculation unit, **343** Table selection unit, **400** Image decoding device, **402** Lossless decoding unit, **421** Assignment control unit, **431** Entropy decoding unit, **432** Debinarization unit, **433** Table storage unit, **434** Debinarization unit, **435** Predicted motion vector selection unit, **436** Motion vector calculation unit, **437** Motion vector storage unit, **441** Distance calculation unit, **442** Table selection unit, **541** Similarity threshold acquirement unit, **542** Similarity calculation unit, **543** Table selection unit, **641** Similarity calculation unit, **642** Table storage unit, **741** Cost function value calculation unit, **742** Cost function value storage unit, **743** Table selection unit, **832** Debinarization unit, **834** Debinarization unit

The invention claimed is:

1. An image processing device comprising:

an assignment control unit configured to control assignment of a binary bit sequence to predicted motion vector select information indicating a motion vector selected as a predicted motion vector, to assign a bit sequence having a shorter code length to select information about a motion vector having a higher designation frequency; and

a binarization unit configured to binarize the predicted motion vector select information with the bit sequence assigned by the assignment control unit,

wherein the assignment control unit comprises:

a distance calculation unit configured to calculate a distance between a current picture and an anchor picture; and

a table selection unit configured to select a table based on the distance calculated by the distance calculation unit, wherein the table designates the bit sequence to be assigned to the predicted motion vector select information in accordance with a type of the motion vector selected as the predicted motion vector, and

wherein the assignment control unit, the binarization unit, the distance calculation unit, and the table selection unit are each implemented via at least one processor.

2. The image processing device according to claim **1**, wherein

the binarization unit binarizes the predicted motion vector select information by using the table selected by the table selection unit.

3. The image processing device according to claim **2**, wherein

the assignment control unit further comprises a similarity calculation unit configured to calculate similarity between peripheral predicted motion vectors, and

the table selection unit selects the table based on the similarity calculated by the similarity calculation unit,

wherein the similarity calculation unit is implemented via at least one processor.

4. The image processing device according to claim **3**, wherein

the assignment control unit further comprises a similarity threshold acquirement unit configured to acquire a similarity threshold indicating a threshold of the similarity, and

the table selection unit selects the table in accordance with a magnitude relationship between the similarity calculated by the similarity calculation unit and the similarity threshold acquired by the similarity threshold acquirement unit, and

wherein the similarity threshold acquirement unit is implemented via at least one processor.

5. The image processing device according to claim **4**, wherein the similarity threshold acquired by the similarity threshold acquirement unit is supplied to another device that decodes encoded data of the predicted motion vector select information.

6. The image processing device according to claim **2**, wherein

the assignment control unit further comprises a cost function value calculation unit configured to calculate a cost function value of the predicted motion vector select information, and

the table selection unit selects the table based on the cost function value calculated by the cost function value calculation unit, and

wherein the cost function value calculation unit is implemented via at least one processor.

7. The image processing device according to claim **2**, wherein information indicating the result of the table selection performed by the table selection unit is supplied to another device that decodes encoded data of the predicted motion vector select information.

8. The image processing device according to claim **1**, wherein

the assignment control unit further comprises a distance threshold acquirement unit configured to acquire a distance threshold indicating a threshold of the distance, and

the table selection unit selects the table in accordance with a magnitude relationship between the distance calculated by the distance calculation unit and the distance threshold acquired by the distance threshold acquirement unit, and

wherein the distance threshold acquirement unit is implemented via at least one processor.

9. The image processing device according to claim **8**, wherein the distance threshold acquired by the distance threshold acquirement unit is supplied to another device that decodes encoded data of the predicted motion vector select information.

10. The image processing device according to claim **1**, further comprising

an encoding unit configured to encode the binarized data obtained through the binarization performed by the binarization unit,

wherein the encoding unit is implemented via at least one processor.

11. An image processing method for an image processing device, comprising:

controlling assignment of a binary bit sequence to predicted motion vector select information indicating a motion vector selected as a predicted motion vector, to assign a bit sequence having a shorter code length to select information about a motion vector having a higher designation frequency, the controlling being performed by an assignment control unit;

calculating a distance between a current picture and an anchor picture, the calculating being performed by a distance calculation unit;

selecting a table based on the calculated distance, the selecting being performed by a table selection unit, wherein the table designates the bit sequence to be assigned to the predicted motion vector select information in accordance with a type of the motion vector selected as the predicted motion vector; and

binarizing the predicted motion vector select information with the assigned bit sequence, the binarizing being performed by a binarization unit,

wherein the assignment control unit, the distance calculation unit, the table selection unit, and the binarization unit are each implemented via at least one processor.

12. An image processing device comprising:

a decoding unit configured to decode encoded data of predicted motion vector select information indicating a motion vector selected as a predicted motion vector;

a debinarization unit configured to debinarize binarized data of the predicted motion vector select information obtained through the decoding performed by the decoding unit, with a bit sequence that is assigned in an assigning operation controlled to assign a bit sequence having a shorter code length to select information about a motion vector having a higher designation frequency; and

an assignment control unit comprising:

a table selection unit configured to select a table, the table designating the bit sequence to be assigned to the predicted motion vector select information in accordance with a type of the motion vector selected as the predicted motion vector; and

a distance calculation unit configured to calculate a distance between a current picture and an anchor picture,

wherein the table selection unit selects the table in accordance with a magnitude relationship between the distance calculated by the distance calculation unit and a distance threshold supplied from another device that has encoded the predicted motion vector select information, and

wherein the decoding unit, the debinarization unit, the assignment control unit, the table selection unit, and the distance calculation unit are each implemented via at least one processor.

13. The image processing device according to claim 12, wherein the assignment control unit is further

configured to control the bit sequence to be assigned to the predicted motion vector select information based on a parameter supplied from another device that has encoded the predicted motion vector select information, and

wherein the debinarization unit debinarizes the predicted motion vector select information under the control of the assignment control unit.

14. The image processing device according to claim 12, wherein

the assignment control unit further comprises a similarity calculation unit configured to calculate similarity between peripheral predicted motion vectors, and

the table selection unit selects the table in accordance with a magnitude relationship between the similarity calculated by the similarity calculation unit and a similarity threshold supplied from another device that has encoded the predicted motion vector select information, and

wherein the similarity calculation unit is implemented via at least one processor.

15. The image processing device according to claim 12, wherein the debinarization unit debinarizes the binarized data of the predicted motion vector select information based on information indicating a table selection result supplied from another device that has encoded the predicted motion vector select information.

16. An image processing method for an image processing device, comprising:

decoding encoded data of predicted motion vector select information indicating a motion vector selected as a predicted motion vector, the decoding being performed by a decoding unit;

selecting a table, the selecting being performed by a table selection unit, wherein the table designates a bit sequence to be assigned to the predicted motion vector select information in accordance with a type of the motion vector selected as the predicted motion vector;

calculating a distance between a current picture and an anchor picture, the calculating being performed by a distance calculation unit; and

debinarizing binarized data of the predicted motion vector select information obtained through the decoding, with the bit sequence that is assigned in an assigning operation controlled to assign a bit sequence having a shorter code length to the select information about a motion vector having a higher designation frequency, the debinarizing being performed by a debinarization unit,

wherein the table is selected in accordance with a magnitude relationship between the calculated distance and a distance threshold supplied from another device that has encoded the predicted motion vector select information, and

wherein the decoding unit, the table selection unit, the distance calculation unit, and the debinarization unit are each implemented via at least one processor.

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